AL-CR-1992-0004

AD-A256 947

ARMSTRONG LABORATORY

# JOB AIDING/TRAINING DECISION PROCESS MODEL


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September 1992

Final Contractor Report for Period March 1990 – April 1990

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# REPORT DOCUMENTATION PAGE

*Form Approved OMB No. 0704-0188*



| 1. AGENCY USE ONLY (Leave blank) | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | September 1992 | Final – March 1990 – April 1990 |

**4. TITLE AND SUBTITLE**

Job Aiding/Training Decision Process Model

**5. FUNDING NUMBERS**

C – F33615-86-C-0545
PE – 62205F
PR – 1121
TA – 11
WU – 43

**6. AUTHOR(S)**

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**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

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**8. PERFORMING ORGANIZATION REPORT NUMBER**

STI-TR-8959-001

**9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)**

Armstrong Laboratory
Human Resources Directorate
Technical Training Research Division
Brooks Air Force Base, TX 78235-5000

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

AL-CR-1992-0004

**11. SUPPLEMENTARY NOTES**

Armstrong Laboratory Technical Monitor: Captain Kara B. W. Martino, (512) 536-2932

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

Approved for public release; distribution is unlimited.

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** (Maximum 200 words)

The objective of the Job Aiding/Training Allocation Technologies (JATAT) Phase 3 project was to further investigate the task analysis and trade-off formulation components of the original JATAT methodology. This report presents the resultant conceptual decision model and its associated process support structure. Also included are the results and conclusions of two independent evaluations performed in support of the development effort. The first is a statistical analysis of the decision attributes which contribute to the aiding/training decision process. The second is an informal investigation of the internal validity of the newly formulated model.

**14. SUBJECT TERMS**

Aiding
Aiding and training
Aiding and training decision support system
Aiding and training trade-off
Decision support system
Training

**15. NUMBER OF PAGES** 148

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | UL |

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

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## PREFACE

This report describes the decision model and associated process support structure of the Job Aiding/Training Allocation Technologies, a conceptual methodology which aids decision makers in determining whether and how tasks should be instructed using training, job-aiding, or some combination of the two methods.

This study was sponsored by the Air Force Human Resources Laboratory under Contract F33615-86-C-0545. The authors gratefully acknowledge the many experts who contributed their time and expertise in our pursuit of their aiding and training decision policies.

## SUMMARY

The objective of the JATAT Phase 3 project was to further investigate the task analysis and trade-off formulation components of the original JATAT methodology. This report presents the resultant conceptual decision model and its associated process support structure. Also included are the results and conclusions of two independent evaluations performed in support of the development effort. The first is a statistical analysis of the decision attributes which contribute to the aiding/training decision process. The second is an informal investigation of the internal validity of the newly formulated model.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the many experts who contributed their time and expertise in our pursuit of their aiding and training decision policies. The preparation of this report and the Job Aiding/Training Allocation Technologies (JATAT) effort it documents were sponsored by the Air Force Human Resources Laboratory under Contract No. F33615-86-C-0545.

## INTRODUCTION

The ever increasing complexity of operational Air Force systems continues to place greater demands on the personnel operating and maintaining them (AFHRL Report, 1986). The increased sophistication of these systems coupled with decreased force levels, declining entry-level skills, and the need to limit military training budgets are forcing Manpower, Personnel, and Training (MPT) agencies to seek more efficient methods of maintaining and improving operational readiness (Booher, 1978; Duncan, 1985). In this environment of "doing more with less", consideration of the issues surrounding job aiding and training are paramount.

One such issue is the selection of appropriate aiding and training methods for a specified task. Technical training, for example, serves as the source of knowledge and skills essential to task performance. In other words, training "creates the potential to perform" while job aiding, in contrast, directly augments the performance (Rouse and Johnson, 1989). Job aids collectively refer to those devices with the capacity to store and retrieve the "How", "What", and "When" information pertinent to the performance of a particular task.

The process of selecting aiding and training is not a simple one. The same technological advances which are responsible for the increased sophistication of operational weapons systems are also enabling the development of a wide variety of aiding devices and training techniques. Selection from among this array of aiding and training alternatives is based on a myriad of interdependent factors such as performance-related effectiveness, development/implementation costs and system design impact.

Further complicating this selection process is the fact that, in most cases, no one method alone completely satisfies the knowledge and skill requirements demanded of the operator/maintainer in performing a specified task. In these situations, there are two equally viable outcomes. First, the aiding/training (A/T) solution may require several complimentary devices and techniques employed in combination. Or, second, a number of independent alternatives (or alternative combinations) may be equally responsive to the task performance requirements. This latter condition generally necessitates some form of trade-off analysis in order to make the final selection. The formulation and evaluation of these A/T tradeoffs are necessary components of the decisions made by MPT analysts, system designers, and personnel supervisors through-out the Air Force.

An example of the considerations of such an analysis might occur as follows. As an information storage device, a job aid facilitates performance by reducing task related memory requirements. This, in turn, reduces the training requirements for that job and generates the potential for reducing recurring resource expenditures. Training, on the other hand, can impart more general knowledge applicable to a variety of related tasks. In this case, the increased initial costs of training a small, multi-disciplinary work force may, in the long-term, be offset by the reduced life-cycle costs of supporting a smaller, more flexible team.

To the extent that tradeoffs analogous to this have been addressed in the past, the analyses have relied heavily on prior experience with similar systems. Typically, these types of analyses have required many person-years of effort. Often, the result has been a time-consuming and expensive effort that provided insights which were too late to be implemented in any substantial way (Rouse and Johnson, 1989). Whether for evaluating current AFS job performance, selecting among new system design alternatives, or ensuring flight-line personnel are task qualified, a methodology for efficiently producing consistent, timely, and supportable A/T decisions is a must.

In response to this need the Armstrong Laboratory, Human Resources Directorate, Brooks AFB, has embraced a new 'technology push' philosophy for developing future A/T decision technologies and is sponsoring the Job Aiding/Training Allocation Technologies (JATAT) program. The purpose of JATAT is to develop a conceptual decision aiding methodology and a corresponding computer-based decision support system prototype designed to assist in identifying applicable A/T alternatives and evaluating combinations. The expected benefits of such a system include faster response times to identified A/T requirements, accurate performance-based recommendations, and reduced military training costs.

This report is divided into three sections; each section representing a cluster of related tasks performed in conjunction with the JATAT project .

The first section contains a short historical summary of the JATAT development work preceding the current phase of effort and a review of the essential components of general decision support systems.

The second section evaluates previous A/T research and describes the JATAT approach. The research evaluation addresses the strengths and weaknesses of several A/T efforts based on a review of available literature. The newly developed JATAT model is an extension of the earlier proposed hybrid methodology designed to overcome the limitations of previous A/T decision approaches. It provides greater detail and a more operationally oriented approach to formulating A/T trade-offs.

And the final section describes two investigative studies performed in conjunction with the current JATAT model development. Study 1 was a statistical survey of expert A/T decision policies. Its purpose was to identify those attributes of A/T trade-offs which influence specific decision outcomes. Study 2 was an informal investigation of the content/construct validity of the JATAT model. This was accomplished through a series of semi-structured interviews with A/T experts familiar with the JATAT model.

## A SYNOPSIS OF PREVIOUS JATAT DEVELOPMENT AND GENERAL DECISION SUPPORT SYSTEM CONCEPTS

### Historical Synopsis

The early part of this effort was devoted to investigating existing computational approaches for evaluating trade-offs between aiding and training This initial investigation identified three distinctly different approaches to resolving A/T trade-offs;

General Aiding/Training Decision Guidelines, Human/System Performance Predictions, and Human/System Performance Simulations.

The use of General Aiding/Training Decision Guidelines is based on a compilation of general knowledge and heuristics for making A/T decisions extracted from the cumulative experience of domain experts and experimental research. The trade-offs are implicit in the guidelines. Thus, to a great extent, the decision making is highly proceduralized, e.g. if situation x, then employ training type y and/or aiding type z (Rouse and Johnson, 1989).

A Human and System Performance Prediction approach involves predicting human/system performance as a function of the applicable A/T alternatives and then using these predictions as a basis for comparing each of the alternatives in question. This approach requires that the relevant trade-offs be explicitly identified prior to the predictive analysis (Rouse and Johnson, 1989).

A Human and System Performance Simulation approach, in contrast, involves simulating the behavior resulting from training and/or aiding which provides the basis for calculating performance for each trade-off to be evaluated. This approach, however, also requires explicit trade-off formulation prior to the simulation execution (Rouse and Johnson, 1989).

While procedurally complete, the use of general A/T decision guidelines lacks the capability to pursue fine-grained trade-offs, or provide thorough explanations for its recommendations. The inability of this approach to pursue fine-grained trade-offs is due to the nature of the guidelines. For example, while a satisfactory A/T solution for situation x may reside in an available decision guideline, it is not reasonable to assume that this guideline applies to all possible deviations from x (i.e., x', x"). Therefore, the best a decision analyst can make using this approach is to select the solution recommended for situation x. This constraint is primarily due to the unavailability of the decision rationale related to corresponding guidelines. While the rationale must exist in order for the guideline to exist, it is seldom documented during the guideline acquisition process.

Performance related approaches, in contrast, can provide clear reasoning for their solutions, but, in the absence of detailed A/T trade-off formulations, are able to give minimal decision aiding support. Further, it is often difficult to obtain the requisite data for these approaches.

In response to these findings, a hybrid methodological framework was constructed which combined the trade-off generation capabilities of the A/T decision guidelines with the reasoning capabilities of the performance-based approaches. In a subsequent effort this framework was formalized into a fifteen step A/T decision methodology. The steps in this methodology encompass; data retrieval, task analysis, trade-off formulation, trade-off evaluation, results interpretation, and analysis/decision summary.

## The Decision Support System

There are two fundamental components of a Decision Support System (DSS) -- the domain knowledge necessary to support the user's decision process and the interface necessary to support the user's application of this knowledge. The completeness of each component is based on the elements summarized in Table 1.

There are two types of domain knowledge associated with an A/T decision support system; knowledge of the A/T decision process, and knowledge of the candidate task classes. A task class is a simple aggregation of tasks with a common purpose; e.g., trouble-shooting, preventative maintenance, clerical, etc.

Each of these knowledge types are essential to the development of the individual components of a DSS. For example, knowledge of the A/T decision domain contributes to: 1) the formulation of an accurate decision model and process support structure, 2) the selection of appropriate A/T decision factors, and 3) the specification of expected levels of output resolution. The remaining task class knowledge helps provide the context-specific relationships among the A/T decision factors and the values of these factors in an operational setting.

In accordance with the objective of this phase of the JATAT effort, this report focuses primarily on the knowledge elements of an A/T decision process model.

| **Knowledge Elements** | **Interface Elements** |
|---|---|
| <u>Decision Process Knowledge</u><br>o Decision Process Model<br><br>o Level of Output Resolution | o Representation of User's Cognitive Model of the Decision Process<br><br>o Support Functionality |
| <u>Task Class Knowledge</u><br>o Decision Factors<br><br>o Relationships Among Factors<br><br>o Factor Values | |

Table 1. Decision Support System Elements

The <u>decision process</u> describes the set of possible paths from problem definition, through the intermediate inputs and decisions, to the final recommendations. This can be further decomposed into two complimentary structures; a *process support structure* and a *general decision model*. The process support structure specifies the appropriate inputs to the general decision model based on the overall context of the decision problem. The general decision model, in turn, is a network of decision paths through which intermediate decision constructs are applied to formulate specific solutions.

It is important to note that the decision process of the DSS need not correspond identically to the decision process of the analyst. It is the role of interface component to translate the dialogue between the user and the DSS into the languages recognized by each. For example, the system requirements, intermediate conclusions, and final recommendations must be presented to the user in terms which relate to the user's perception of the decision process. Likewise, the user's inputs must be consistent with the system's process requirements and in a computationally usable form.

Decision factors are the characteristics of the task, personnel, equipment, and environment which influence the outcome of the decision model. Selecting the factors which are appropriate to a specific analysis is a function of the underlying basis of the A/T decision, the expected level of output resolution, and the availability of appropriate data.

The underlying basis of an A/T trade-off decision can either be based on human-system performance attributes or operational constraints. For example, an approach based on performance attributes will emphasize factors such as personnel experience, task frequency, and equipment complexity. In contrast, decisions based on operational constraints will emphasize cost and resource availability.

Relationships among decision factors are represented as intermediate decision paths throughout the general decision model. Collectively, each of the intermediate decision points and their respective paths form a contextual map/network of the overall problem space. The path chosen, therefore,in any given analysis will represent the specific context of the operational environment in question. The characteristics of these relationships are essential to the choice of the decision model employed and, hence, must be understood early in the decision process.

The values associated with each of the selected factors provide the context-specific data which guides selection of the decision paths. Two issues directly related to these decision factor values include; 1) the availability of the supporting data, and 2) the intended level of resolution of the process. Data availability can be further categorized into three distinct levels: 1) that which is readily available in a directly usable form, 2) that which requires some degree of pre-processing (i.e., transformation in terms of abstraction or aggregation), and 3) that which requires new or modified data acquisition procedures. A high level of resolution requires quantitative input data, while a low level of resolution, on the other hand, requires only qualitative inputs.

The level of resolution of a DSS defines the level of detail of both the system inputs and system outputs. For example, input decision factors can exist at various levels of precision (i.e., aptitude ratings of high, medium, and low versus quantitative ASVAB scores). Similarly, system A/T outputs can be represented as either broad classes (e.g., train vs. aid), categories within classes (e.g., passive training techniques vs procedural aids), or instances of categories (classroom lecture vs flip-chart checklist). The intended level of resolution will have a major impact on the extent of the decision network contained within the general decision model.

## REVIEW OF PREVIOUS RESEARCH AND DESCRIPTION OF THE JATAT MODEL

The results of this work, prior to this report, include: 1) a comprehensive review of current A/T literature, and 2) the formulation of a JATAT decision model. The review found on the following pages discusses the strengths and weaknesses of current A/T research and several current A/T decision models. The JATAT approach describes the current JATAT decision process support structure and the general decision model. The discussion addresses each stage of the process support structure in detail and describes the role of the general decision model at each appropriate juncture.

### Review of Available Aiding/Training Literature

A review of available A/T literature indicates that the majority of early research concerning A/T decision-making focused on context-free or limited context applications. Further, the majority of decision guidelines produced by these efforts related specific A/T solutions to specific decision factors, without regard to intermediate relationships. As indicated earlier, decision models devoid of context and intermediate decision relationships are likely to have limited application to real-world problems.

Additionally, the models generated by this previous research have generally employed only linear statistical models or deterministic, decision tree approaches. Statistical approaches attempt to quantify the relationships between the independent and dependent variables associated with the decision (Irvin, Blunt, and Lamb, 1988). In contrast, a decision tree approach represents a series of empirically based rules defining the relationships among known input values and expected outcomes (Booher, 1978, Goins, Marshal, and Levine, 1989). A third potential approach is to apply a knowledge-based system. This approach employs rules/heuristics which express relevant relationships and solutions to a number of related problems based on expert experience and empirical research.

One method for comparatively evaluating these approaches is to ordinally rank the degree of explanation they can provide pertaining to a particular decision analysis.

A linear statistical approach, for example, employs weighting values as a basis for defining the relationships between variables and the recommended A/T solutions. The explanation available in this approach for making these recommendations is inherent in the progressive refinement and use of statistical techniques such as discriminant function analysis, factor analysis, principal component analysis, cluster analysis, or other similar multivariate procedures. Through these progressive iterations the researcher eliminates or modifies variables which do not contribute to deriving the A/T solution. This "model" can then be used to determine the A/T recommendations for tasks for which a user can provide the requisite data. As indicated earlier, the rationale for recommending a specific A/T solution set is implicit in the model and not directly accessible to the user. Therefore, in order to offer the task by task explanation most useful to user of a JATAT decision model it would be additionally necessary to generate a semantic interpretation of the specific weights and/or functions as they apply to an individual task.

The empirically derived rules of a decision tree represent a highly rigid application of a predetermined reasoning process. Although a decision tree approach may frequently employ correlational values to guide certain intermediate level decisions the capability exists to describe the decision path taken to arrive at the recommended solution. This increased degree of available explanation is, however, still constrained by the inflexibility of the predetermined reasoning process.

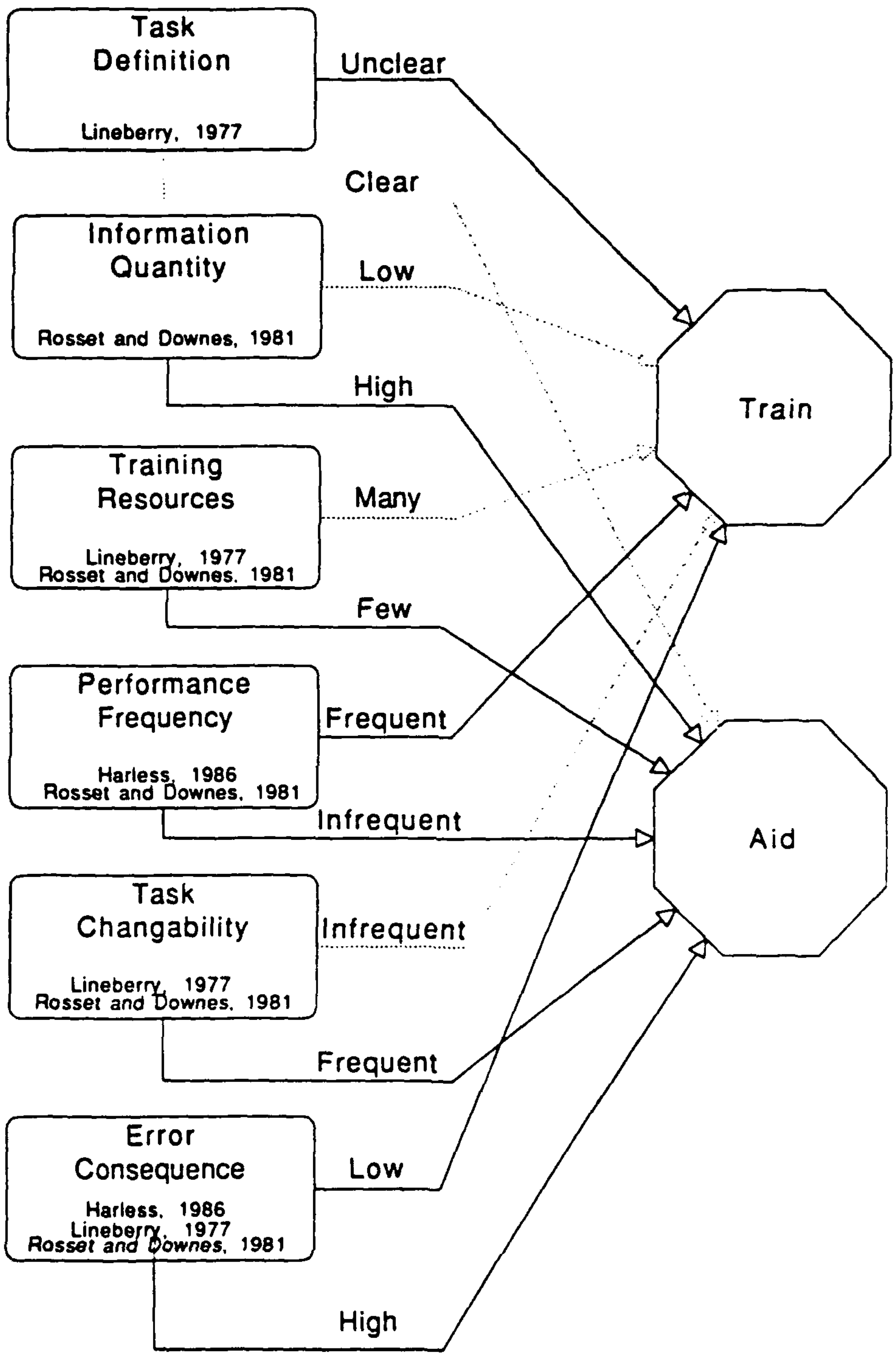
The expert rules of a knowledge-based approach, in contrast, enable reasoning about the "How's" as well as the "Why's" of the decision process. The knowledge employed by this type of approach includes both specific relationships and intermediate decisions as well as supporting rationale and other general domain-related heuristics. It is likely that the relationships among the decision factors, intermediate constructs and recommended solutions would be based on empirically derived correlational values. Knowledge of the supporting rationale provides an unparalleled explanatory capability for accompanying recommended solutions. Additionally, the inclusion of other general domain-related heuristics enables a much more flexible response to an A/T decision problem.

## General Conclusions

The following paragraphs summarize the issues and observations identified and generated during our review of the current A/T literature.

1. The majority of efforts in this area have only considered the decision at the level of *training* and/or *aiding*. Only Booher (1978) attempts to specify particular types of training or aiding for given task- and personnel-related conditions.

2. Most articles indicate whether to train or aid if a particular condition is satisfied, but not what to do if the condition is not satisfied. Choice of the alternative option is, therefore, either not as clearly defined and left to the analyst's discretion, or not fully considered as part of the available literature. For example, while it is stated that tasks with high information quantity should be aided, it is never explicitly stated what should be applied to tasks with low information quantity. Figure 1 is a sampling of several decision factors addressed in the current A/T literature in which this phenomenon is manifested. (The appropriate literature source is sited in each factor box.) The solid lines represent those relationships explicitly identified in the literature. The dashed lines represent extrapolations which have no empirical basis.




- Solid lines indicate relationships drawn directly from specifie literature.
- Dashed lines indicate extrapolations.

Figure 1. Factor-Solution Relationships from Previous Research

3. Another issue indirectly presented in Figure 1 is the lack of specified relationships among input variables. This situation can frequently result in conflicting recommendations. For example, how is the decision resolved if error consequence is low (indicating "train") but frequency of performance is infrequent (indicating "aid")?

4. Figure 2, a graphic representation of the 20 A/T decision rules specified by Goins, Marshal, and Levine (1989), addresses the above issue by revealing the potential complexity of relationships among variables. For example, Rule #11 of Goins et. al. (1989) states that "If an equipment hazard does not exist, and the task is critical, and the performance frequency is less than 3 months, then train".

5. While the representation in Figure 2 shows an early attempt to address the complexity of factor relationships, this representation, like others, fails to address the possibility of A/T trade-offs. In fact, the majority of current A/T literature avoids those cases in which a combination of aiding and training should be employed. This, unfortunately, constitutes a large portion of A/T decision situations. For instance, it is highly likely that a task with high error consequence will be trained as well as aided.

6. Conceptual and operational definitions are frequently unspecified. And, in those cases in which the variables are specified, they are frequently internally ambiguous and ill-defined, and inconsistent with the definitions of similar factors in other literature. For example, how many is "many" and how few is "few" training resources? (See Appendix A)

7. Finally, the rationale for the decisions are not explicitly documented.

Our conclusion is that no one model or approach completely satisfies the JATAT DSS requirements. Hence, a hybrid model which incorporates the strengths of each of these models, where appropriate, is necessary. This is the role of the general decision model and process support structure described in the following sections.

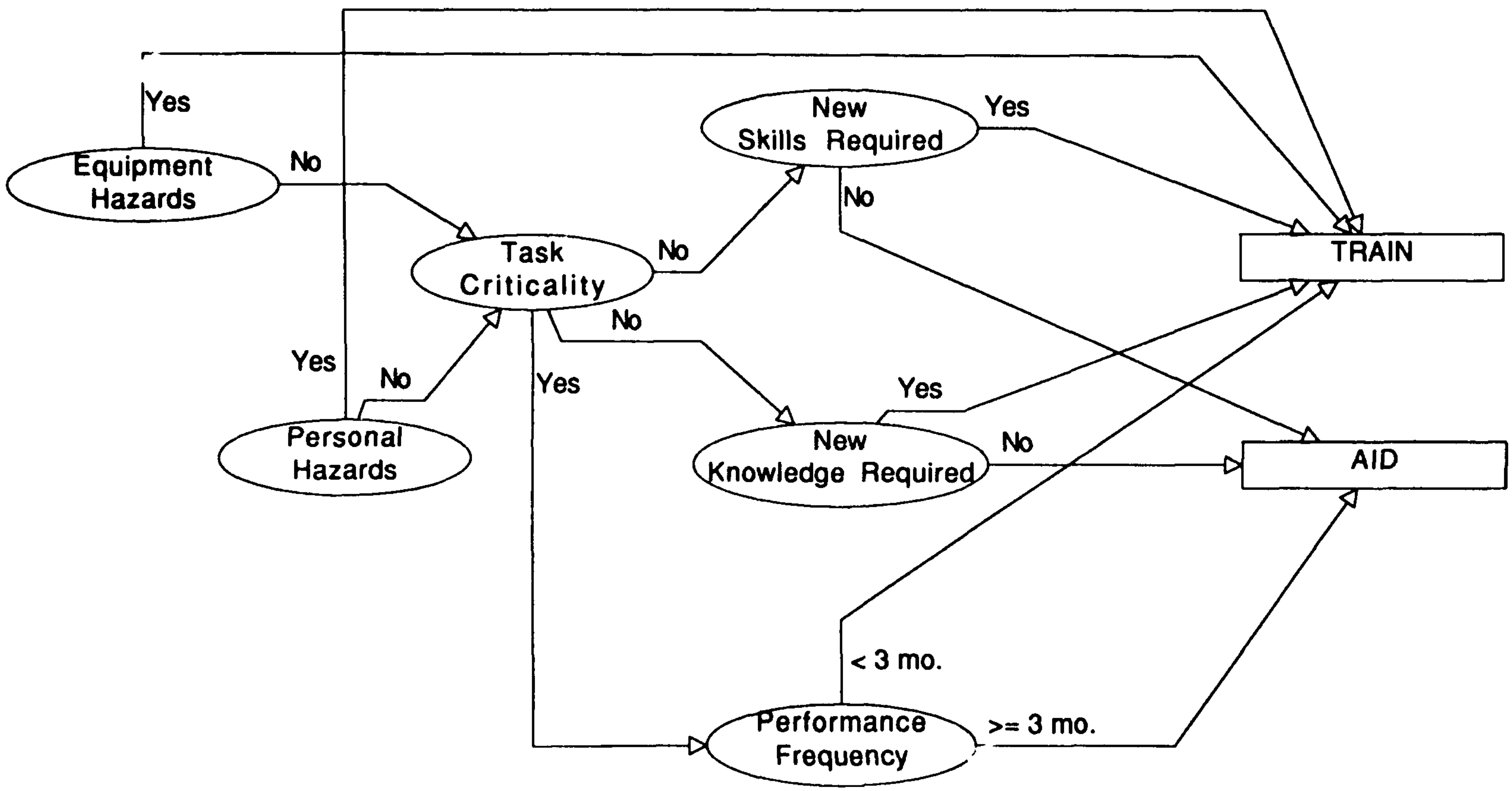



Figure 2. Variable Relationship Network -- Goins, Marshal, and Levine (1989)

## The JATAT Approach

The first step in developing any decision model is to specify the context and boundaries of the problem space. In accordance with the focus of this phase of the JATAT effort the problem is practically bounded by, and the representation correspondingly structured after, the first seven steps of the original fifteen step methodology. These include:

| |
|---|
| * Understand the Job |
| * Decompose via a Task Taxonomy |
| * Assess Human Limitations, Abilities, and Preferences |
| * Map Limitations, Abilities, and Preferences to a Taxonomy of Training Alternatives |
| * Map Limitations, Abilities, and Preferences to a Taxonomy of Aiding Alternatives |
| * Make Obvious Choices |
| * Coalesce Interdependent Trade-offs |
| • Choose Measures of Performance |
| • Choose Input-Output Representations |
| • Identify Requisite Structure and Parameters for Representations |
| • If Necessary, Represent Learning Process |
| • Apply Methods of Analysis to Representations |
| • Interpret Results |
| • Compile Assumptions and Consequences of Trade-offs |
| • Form Sets of Trade-offs with Consistent Assumptions and Consequences Regarding Personnel |

Table 2. Fifteen Steps of Original JATAT Methodology

The culmination of this decision model development is represented in the two part process support structure diagram in Figures 3 and 4 and the general decision model to be discussed later. The process support structure is responsible for providing the operational context for the decision model and for guiding the task

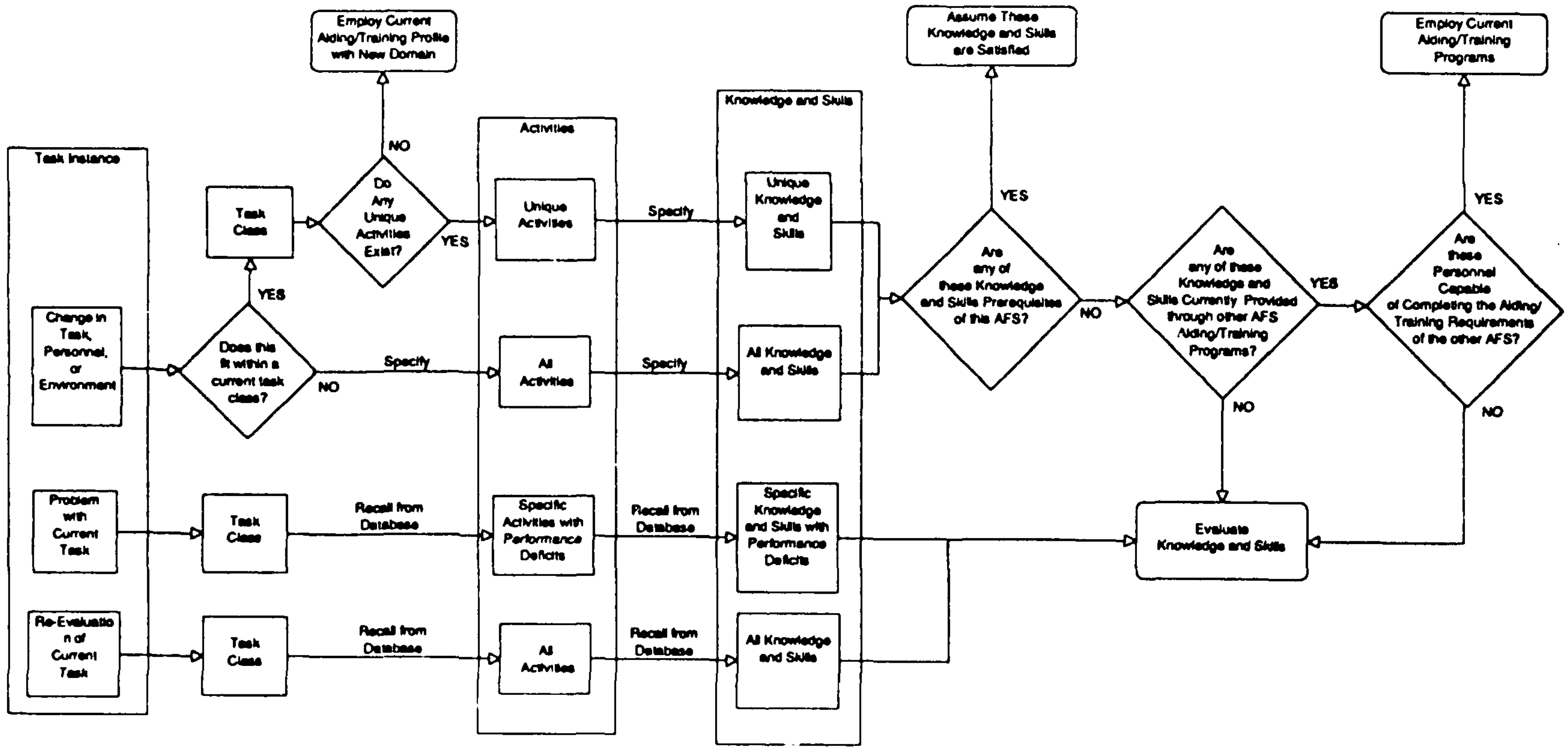



Figure 3. The JATAT Process Support Structure (Part 1)

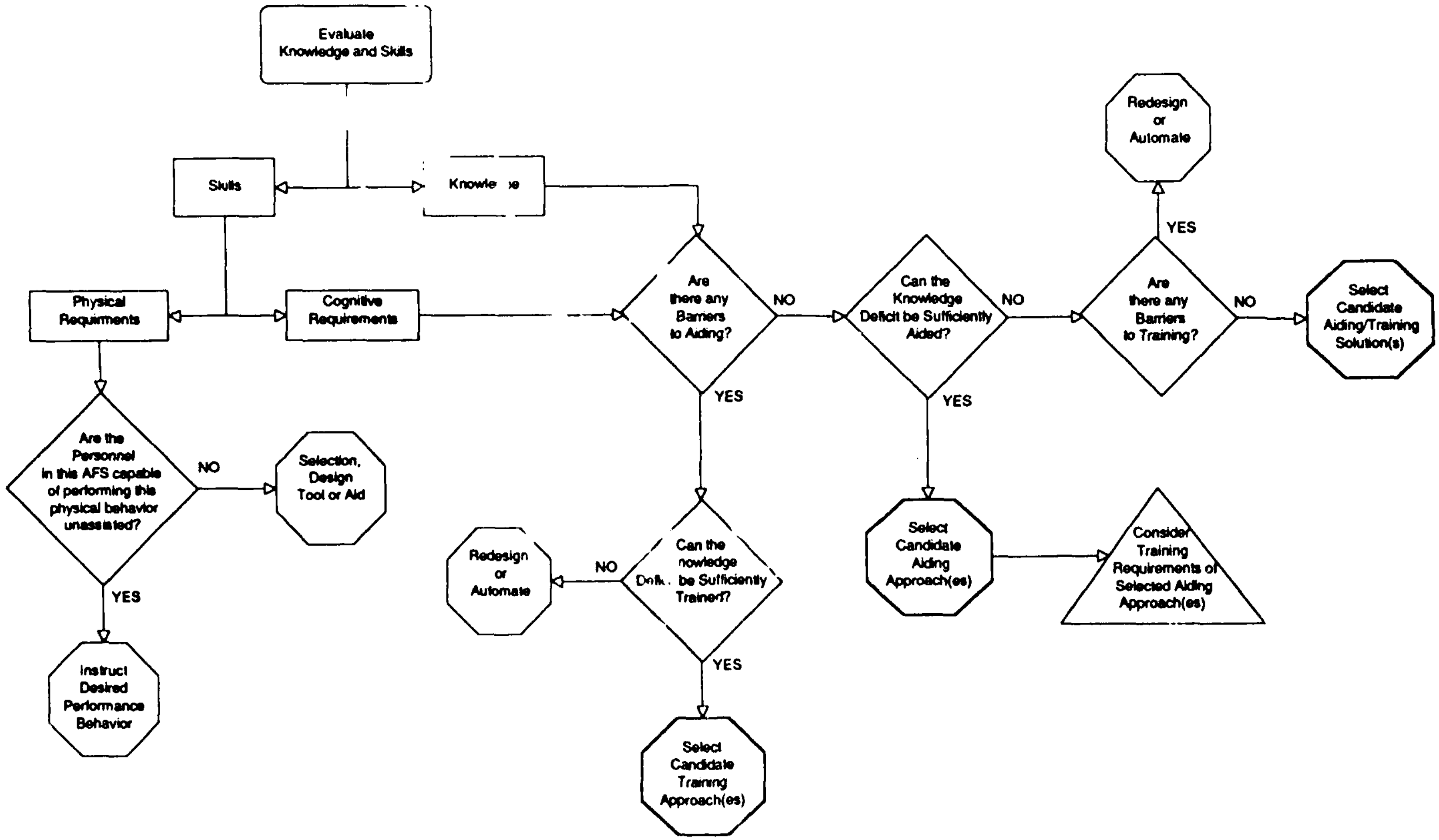



Figure 4. The JATAT Process Support Struture (Part 2)

analysis/decomposition process which provides the inputs to the general decision model.

Part One (Figure 3) of the process support structure describes an operationally oriented task analysis process. The architecture of this process is based primarily upon the availability of data from current Air Force data sources (i.e., the Occupational Research Data Bank, and the more recent AFS Task Analyses documents). Part Two (Figure 4) describes an attribute/performance based analysis of the knowledge and skills derived from the preceding task analysis. These two parts can be further divided into the following five process segments:

- The Decision Process Entry Points
- Activity, Knowledge, and Skill Identification
- Relevant Knowledge and Skill Specification
- Skill Analysis
- Knowledge Analysis and Aiding/Training Selection

The Decision Entry Points

There are essentially three potential reasons for employing the JATAT decision process. First, a new system is being developed which, when implemented, will require operators and maintainers to perform a series of new tasks. In this case, each of the new tasks would be independently evaluated using the JATAT DSS. Second, current performance on a particular task within the operational environment is unsatisfactory. This task would be evaluated to identify potential sources of deficiencies and alternative approaches to aiding or training. And finally, an Air Force MPT organization is investigating opportunities for reduced training resource expenditures. Candidate tasks would be analyzed through JATAT to determine alternative methods for augmenting or enhancing performance. These alternatives can then be comparatively evaluated on a cost basis.

The shaded portion of Figure 5 represents the decision entry points of the process support structure. This same shading scheme will be used in Figures 6 - 9 to indicate

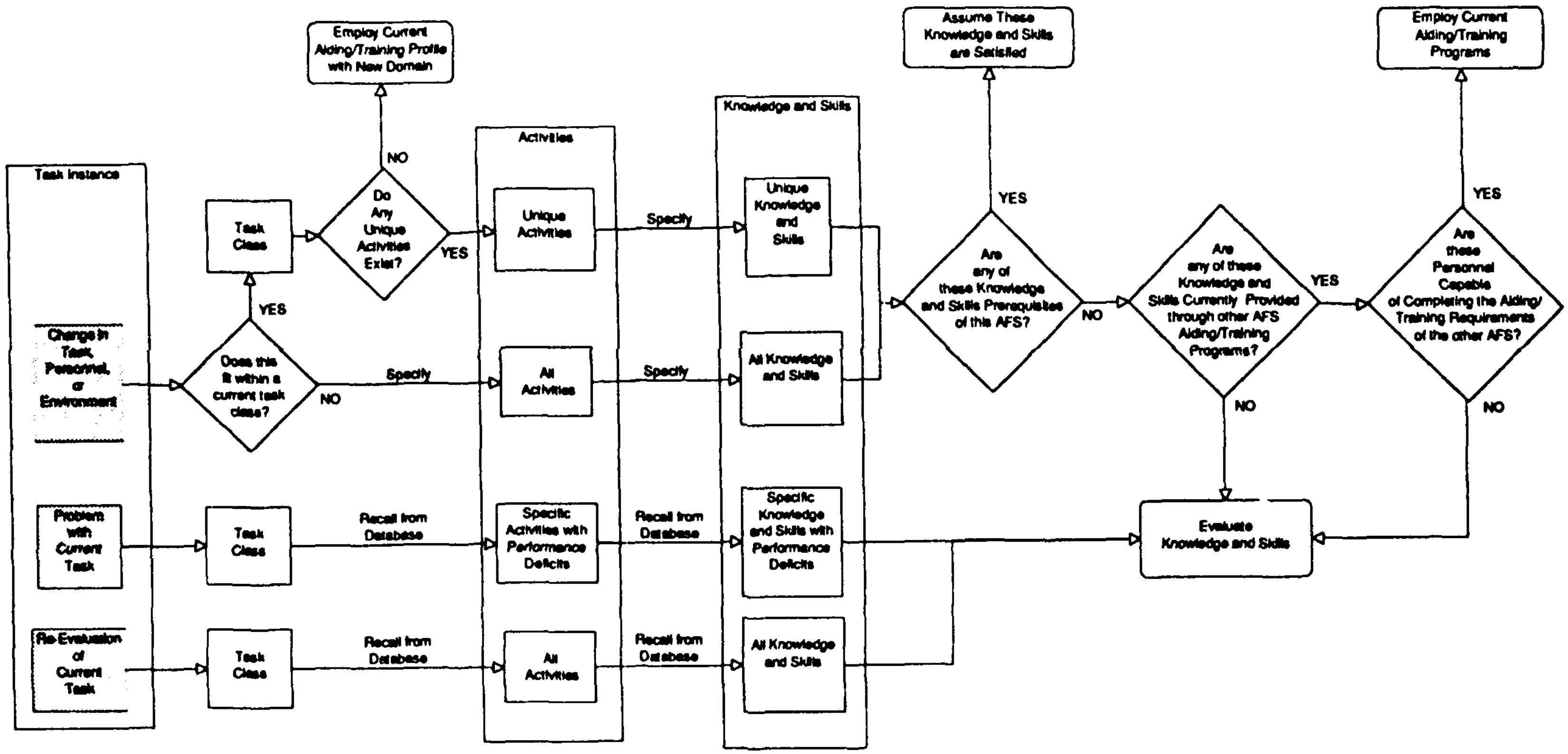



Figure 5. The Decision Entry Points

those components of the process support structure which comprise each of the four remaining process segments.

## Activity, Knowledge, and Skill Identification

A thorough task decomposition of this nature can be difficult but is a necessary component of any task related decision process. The current decomposition process is based on the activities, knowledge and skills related to the task in question. Specifically, each task is composed of a number of related (either temporally, functionally, or otherwise) activities. Each activity has associated with it several knowledge and skill components. The goal of this decomposition process is to identify all the related activities, knowledge and skills pertinent to the task. (See Figure 6.)

This identification process quickly becomes intractable if the analyst is unfamiliar with the domain in question. Fortunately, recent OSR efforts have begun to compile activities, knowledge and skills required for each of the task responsibilities of a given Air Force Specialty (AFS). (Ref: 454X0 Task Analysis). Task decomposition within the JATAT decision process model is based upon these OSR analyses. As mentioned in an earlier JATAT report (Zenyuh, Frey, Rouse, and Lamb, 1990) consistent definitions of tasks, activities, knowledge, and skills are requisite to the useful application of a decision support system.

These requisite knowledge and skills define the minimum proficiency requirements for each activity and task performance. Minimum proficiency, in this case, indicates that the operator/maintainer can satisfy the minimum performance requirements for the defined task. Current Air Force training procedures attribute no additional benefit to performance capabilities beyond the minimum requirement.

## Relevant Knowledge and Skills Specification

Once the task decomposition is complete and all the related activities, knowledge and skills are identified, it is necessary to select the subset of knowledge and skills which is to be analyzed. (See Figure 7.) The purpose of this selection process is to

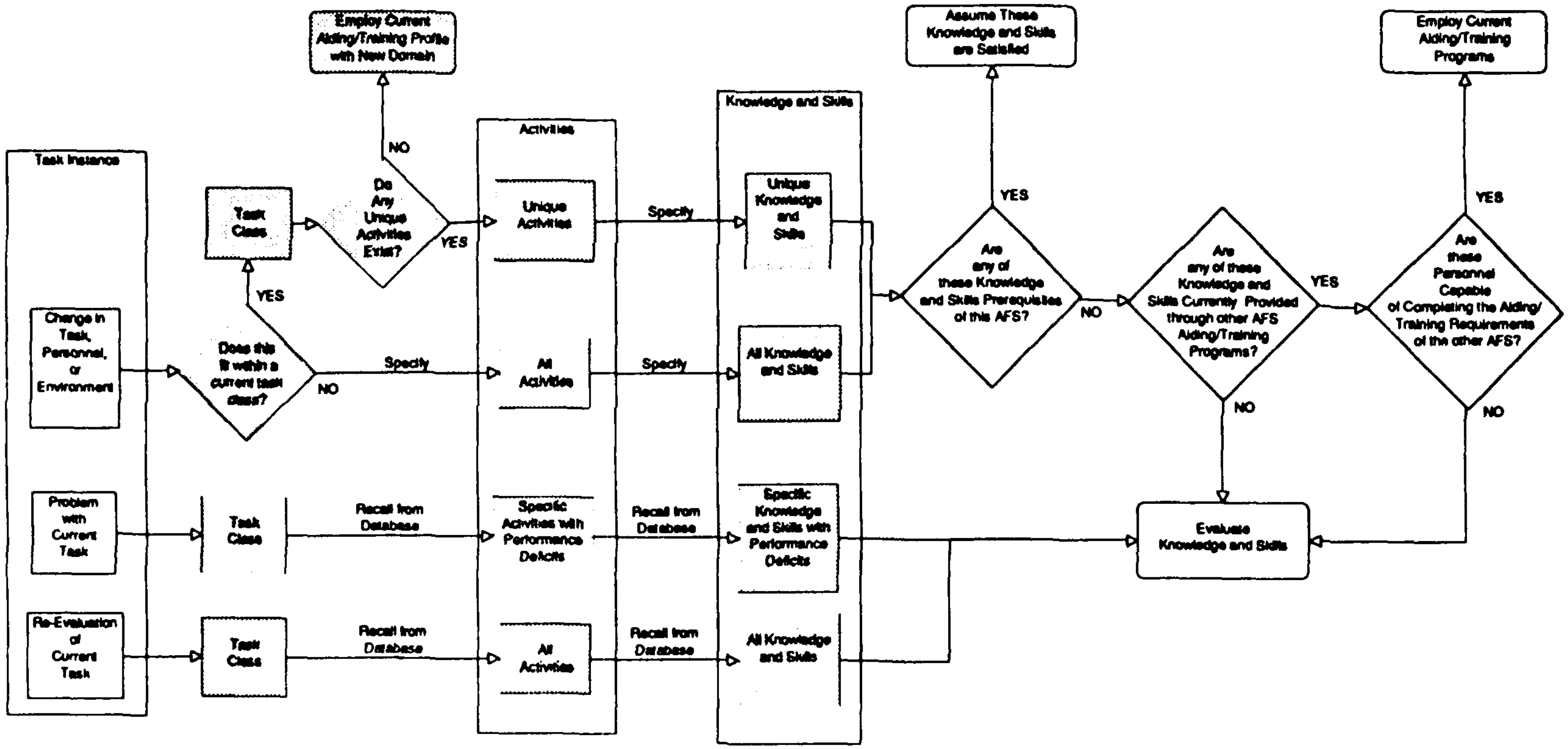



Figure 6. Identification of Activities, Knowledge, and Skills

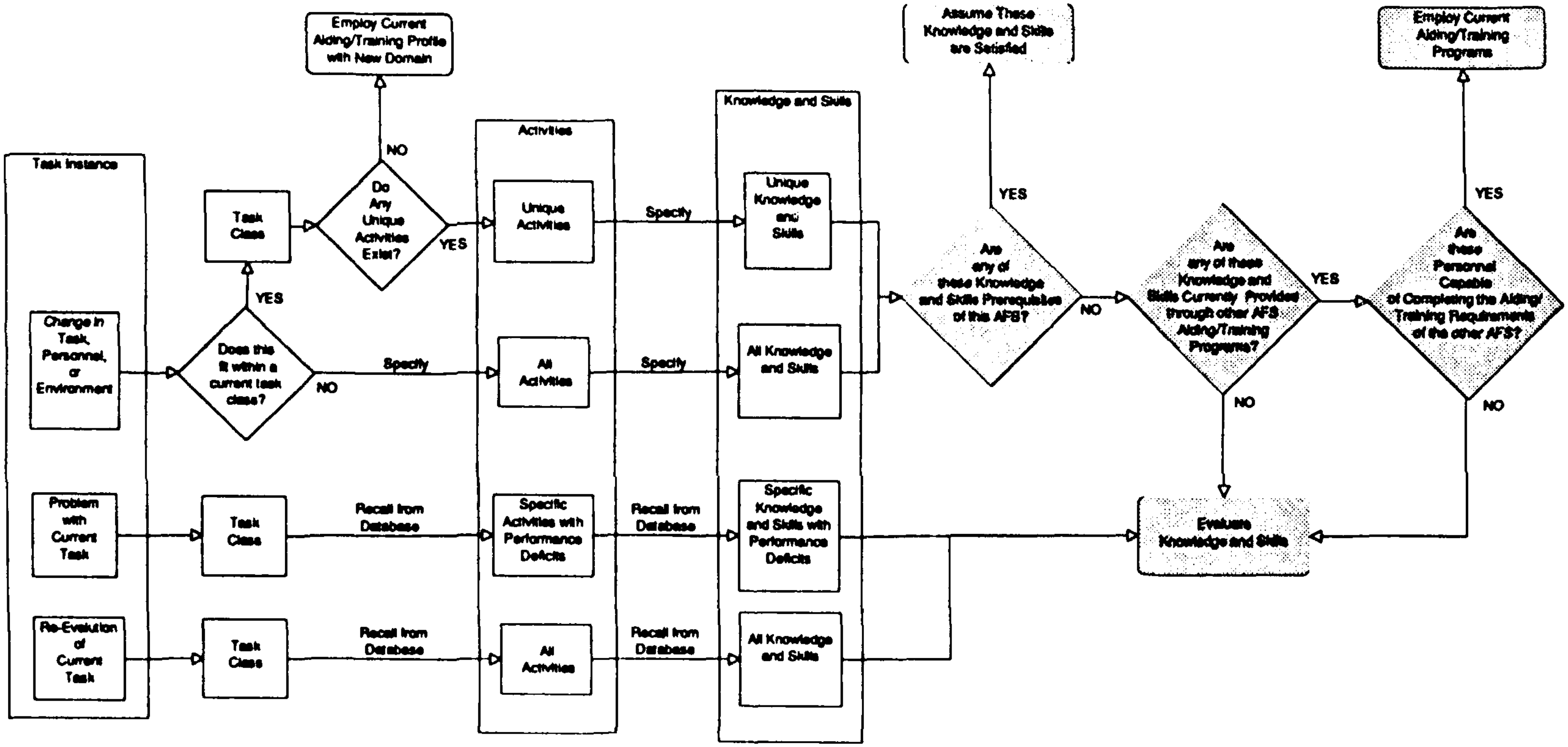



Figure 7. Specification of Relevant Knowledge and Skills

eliminate those knowledge and skills for which successful training programs already exist. More specifically, a decision maker must determine; 1) if any of these requirements are satisfied as part of the training program for the same specialty - for other tasks, or 2) if any of these requirements are satisfied as part of the training program for a different specialty - same task. Conceivably, this could be assisted by employing an automated pattern matching algorithm to compare these knowledge and skills between related databases.

This process, as currently envisioned, would rely heavily upon existing operational AFS training programs -- each particular program having specific knowledge and skills which are expected to be acquired by the students during their training. For example, Jet Engine Maintenance personnel are already able to "Recall Power Supply Handling Procedures" as a result of their initial aiding and training. Therefore, it would be unnecessary to perform an in depth A/T analysis to determine how best to enable Avionics Maintenance personnel to perform a similar function.

### Skill Analysis

Skill analysis is based on further decomposition of their physical and cognitive components. (See Figure 8.)

The physical requirements of a task can easily be evaluated against the known physical capabilities of the personnel (e.g., height, weight, strength, etc.). If deficiencies exist, the decision-maker has the options of either recommending the use of a tool to augment performance or re-establishing the qualification criteria for personnel selection. If the personnel are physically qualified, the analyst can recommend instruction of the desired performance behavior.

Cognitive requirements are simply analyzed as additional requisite knowledge components.

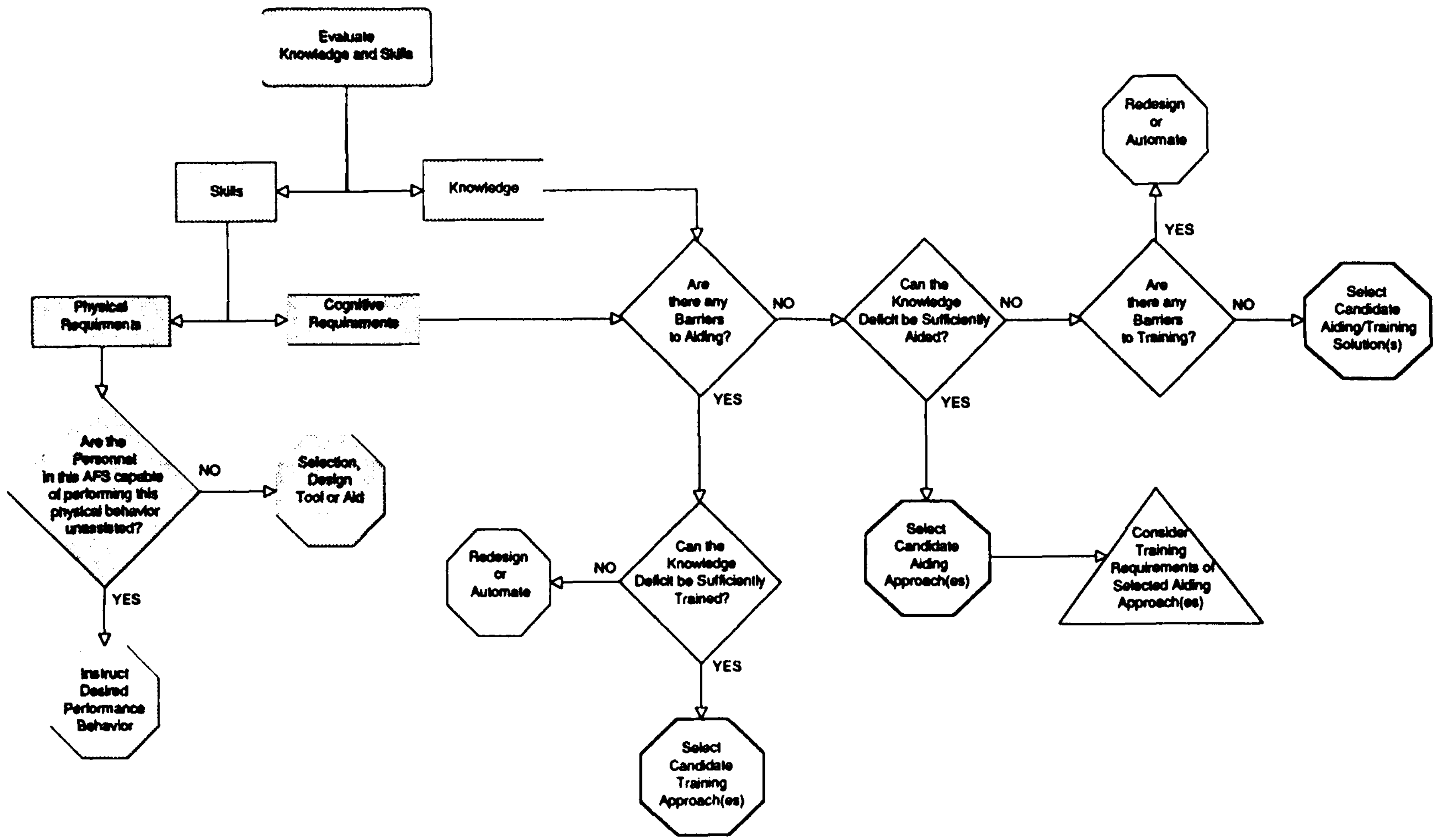



Figure 8. Skill Analysis

## Knowledge Analysis and Aiding/Training Selection

Once the list of knowledge components to be analyzed is established, the decision-maker is confronted with a series of evaluations (decision points), each with the purpose of more narrowly focusing the problem space. Each subsequent decision is directed at eliminating another portion of the problem space. The ultimate result being the determination of the most appropriate A/T solution(s) for the knowledge requirement. The Knowledge Analysis and Aiding/Training Selection segment of the process structure, highlighted in Figure 9, represents this decision flow process.

It is, as yet, unclear whether each knowledge component must be independently analyzed for A/T alternatives or if they can be aggregated across some underlying characteristic and analyzed as a group. While this issue is worthy of further research, it is beyond the scope of the current effort.

The first decision in this segment of the process structure is to assess the potential "barriers to aiding". The objective at this point is to determine if it is at all possible to efficiently aid any component of the required knowledge. (This is not an issue of whether or not an applicable aid can completely satisfy the knowledge requirements -- this issue is addressed at a subsequent decision point)

The rationale for making this determination first is that aiding is generally more cost effective than training. Therefore, the philosophy is simply to "aid if you can". This is further evidenced in the decision flow diagram in that the aiding related decisions are always resolved prior to addressing training related decisions.

Barriers to aiding define a specific cluster of decision factor values (e.g., high task performance rate) which prevent the useful application of known aiding approaches to a particular knowledge and task. These can be categorized as those which prevent aiding for physical (e.g., limited space), technical (e.g., aid technology insufficient), temporal (e.g., high task rate prohibits referencing aid), or psycho-social reasons (e.g., credibility of performer degraded by existence of aid).

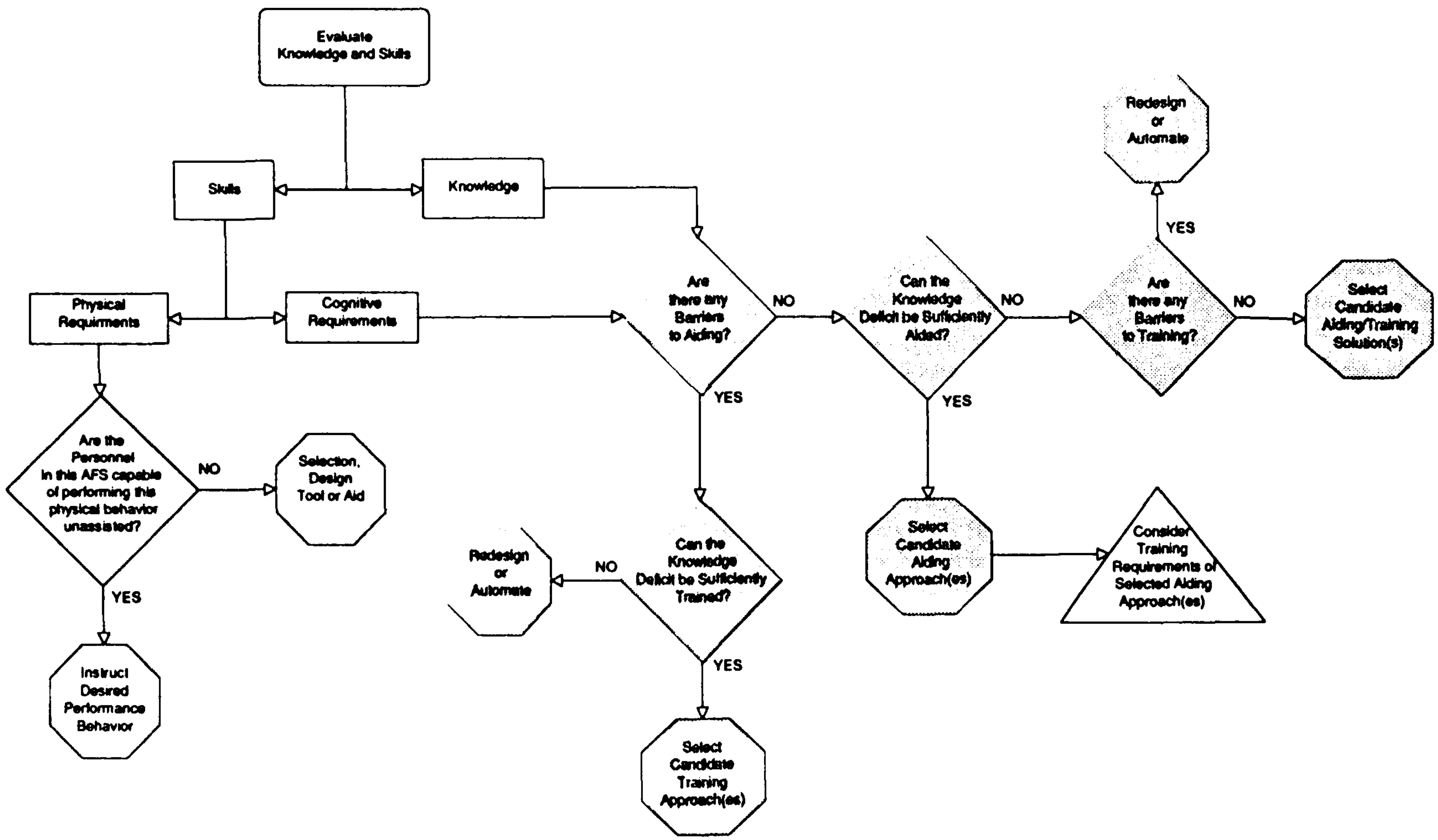



Figure 9. Knowledge Analysis and Aiding/Training Selection

Figure 10 represents a time based model of a potential barrier to aiding. In this case, the time required to perform the task exceeds the time available and a task redefinition is recommended.

Given that some barrier(s) to aiding exists, (i.e., there is no type of aiding which can, to some level, satisfy the knowledge requirement) then training must be considered as the only feasible alternative. If training alone can completely satisfy the target knowledge requirements, then candidate approaches can be considered. Where training, as such, is not feasible, the task must be either automated or redesigned.

On the other hand, if aiding is feasible, then it must be determined if an aiding approach(es) (or combinations, thereof), which can fully satisfy the target knowledge requirements, exists. If so, then candidate aiding approaches can be considered. (Note that, in this case, the decision-maker may also need to address the potential training requirements of the selected aiding approaches.)

Assuming that aiding is not prevented by any known *decision factors, but will not* singularly satisfy the knowledge requirement, training should be considered as a component of the solution. If, at this point, there are any physical, technical, temporal, or psycho-social barriers to training, the task is intractable from an A/T perspective and must be automated or redesigned. Otherwise, candidate A/T combination solutions can be considered.

It is important to notice that, in each case, the A/T recommendations are based purely on performance attributes. Operational issues, such as development and life-cycle cost and geographical availability, while essential to a complete evaluation, are better analyzed using other MPT models (e.g., TDS).

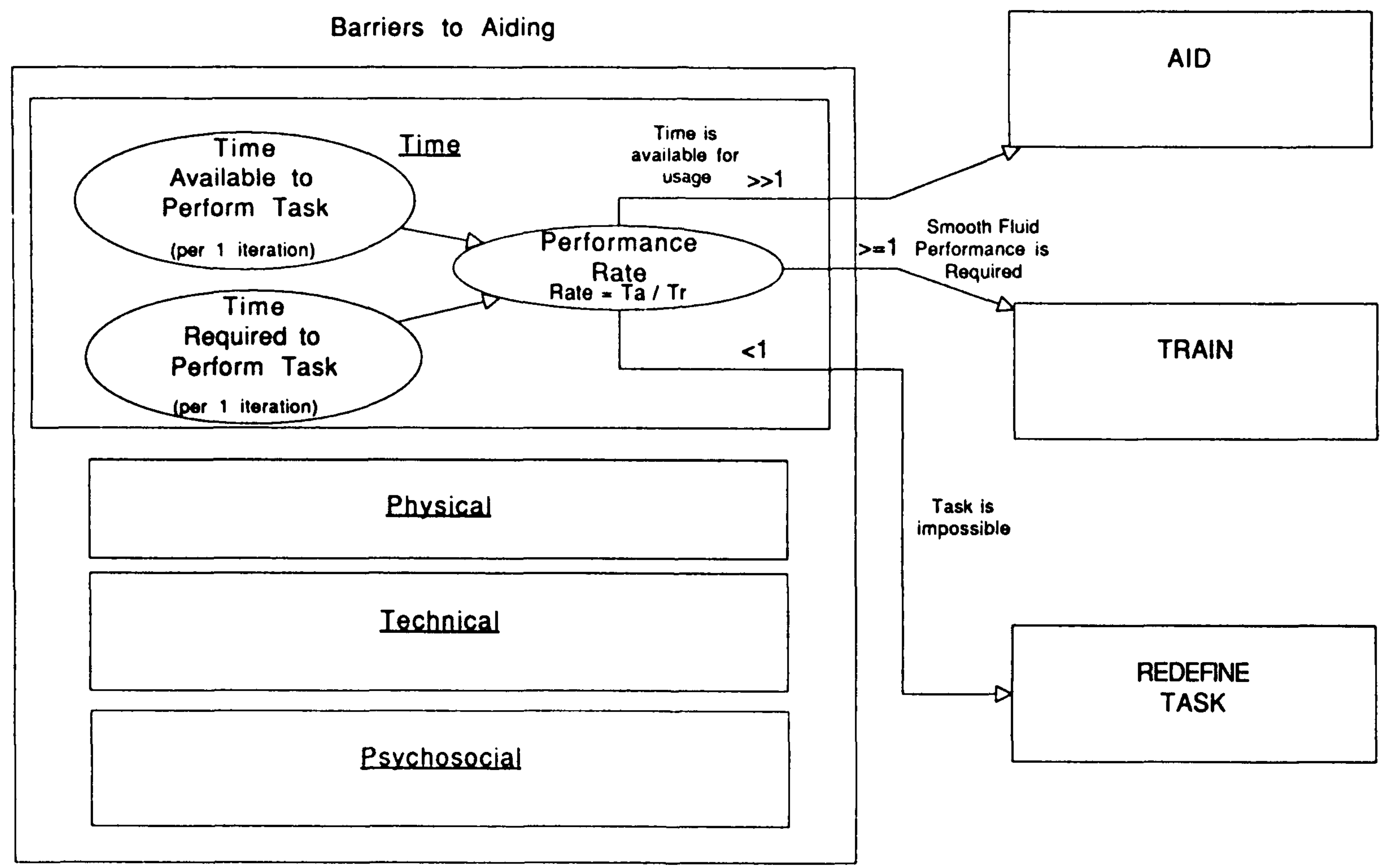



Figure 10. Barriers to Aiding -- A Temporal Model

## The JATAT General Decision Model

### The Concept

The simplicity of the Knowledge Analysis and Aiding/Training Selection segment of the decision process is deceiving. In actuality, each decision point represents a complex confluence of knowledge characteristics, task-, personnel-, equipment-, and environmental-factors and their underlying interdependencies. These factors and interdependencies, as well as the candidate A/T solutions, form the basis for the particular decision model employed at each respective point. These individual decisions can then be aggregated into a composite model which represents the boundaries and context of the entire problem space. For the purpose of this report, the composite model developed as part of this effort will be referred to at the JATAT General Decision Model.

As mentioned earlier in this report, the characteristics of these factors and their relationships greatly influence the architecture of a model used to represent a decision process. For the current A/T decision model, the most formative characteristic influencing its design is the large number of task-related factors and their interrelationships.

This condition creates several problems. The first obvious difficulty, is determining how each of the numerous variables should affect the decisions in general, and how such relationships are affected, in particular, by differing contexts. Secondly, if all possible interactions are considered, data collection requirements become intractable -- yet, if data collection is compromised, parameter estimates have wider ranges of uncertainty and predictions are subject to larger errors. Finally, even if relationships can be identified and parameters appropriately estimated, without some form of intervening assistance, the whole approach may be rather opaque since the user may have difficulty intuiting which factors are playing what roles in the decision process.

One approach is to employ intermediate constructs/classifications which map the input variables to the proposed solutions and represent the entire decision process as a network of these intervening relationships (Chandrasekaran and Goel, 1988).

The current JATAT general A/T decision model employs one such approach. (See Figure 11.) Task-related factors are represented as inputs and constraints, candidate A/T solution sets are represented as outputs, and the decision paradigm is represented as a reasoning process based on intermediate constructs.

Addressing the model in detail, each of the task, personnel, equipment and environmental characteristics/factors place various resource demands on the individual performing that task. These demands, in turn, have certain implications for the learning and/or task performance capabilities of the personnel. Potential sources of resolution for these implications exist in the form of general aiding or training approaches. Once an A/T approach(es), which satisfactorily responds to these implications, has been identified, a specific aiding device or training technique can be selected.

This representation; input data to abstract requirements, abstract requirements to abstract solutions, and finally abstract solutions to a specific solution(s), portrays the pattern of intermediate inferences associated with the decision process. This is commonly referred to as an inference structure representation (Steels, 1990).

There are three advantages to applying an inference structure approach to the general A/T decisions model. One, it presents the underlying structure of the A/T decision rules and heuristics. This permits subjective evaluation, by other domain experts, of the reasoning underlying the variable relationships, implicit in the intermediate constructs. Two, it shows the relationships among the rules/heuristics. The benefit of this manifestation is two-fold. First, the knowledge acquisition process can be more accurately constrained to the domain knowledge of interest. And second, it enables an automated system to provide explanations for its recommendations. Third, the same structure can be applied to widely diverse domains and tasks (Steels, 1990).

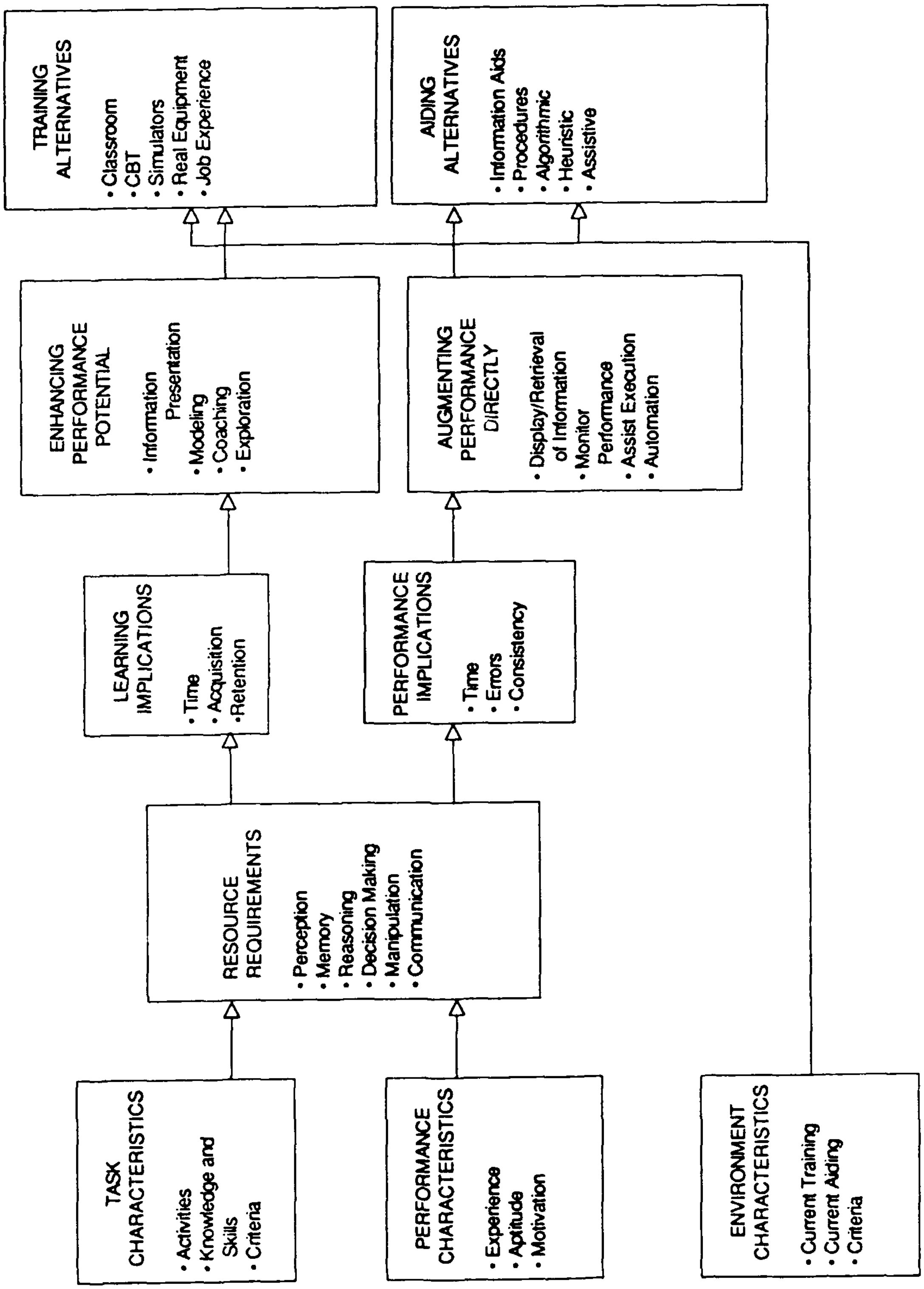



Figure 11. General Decision Model

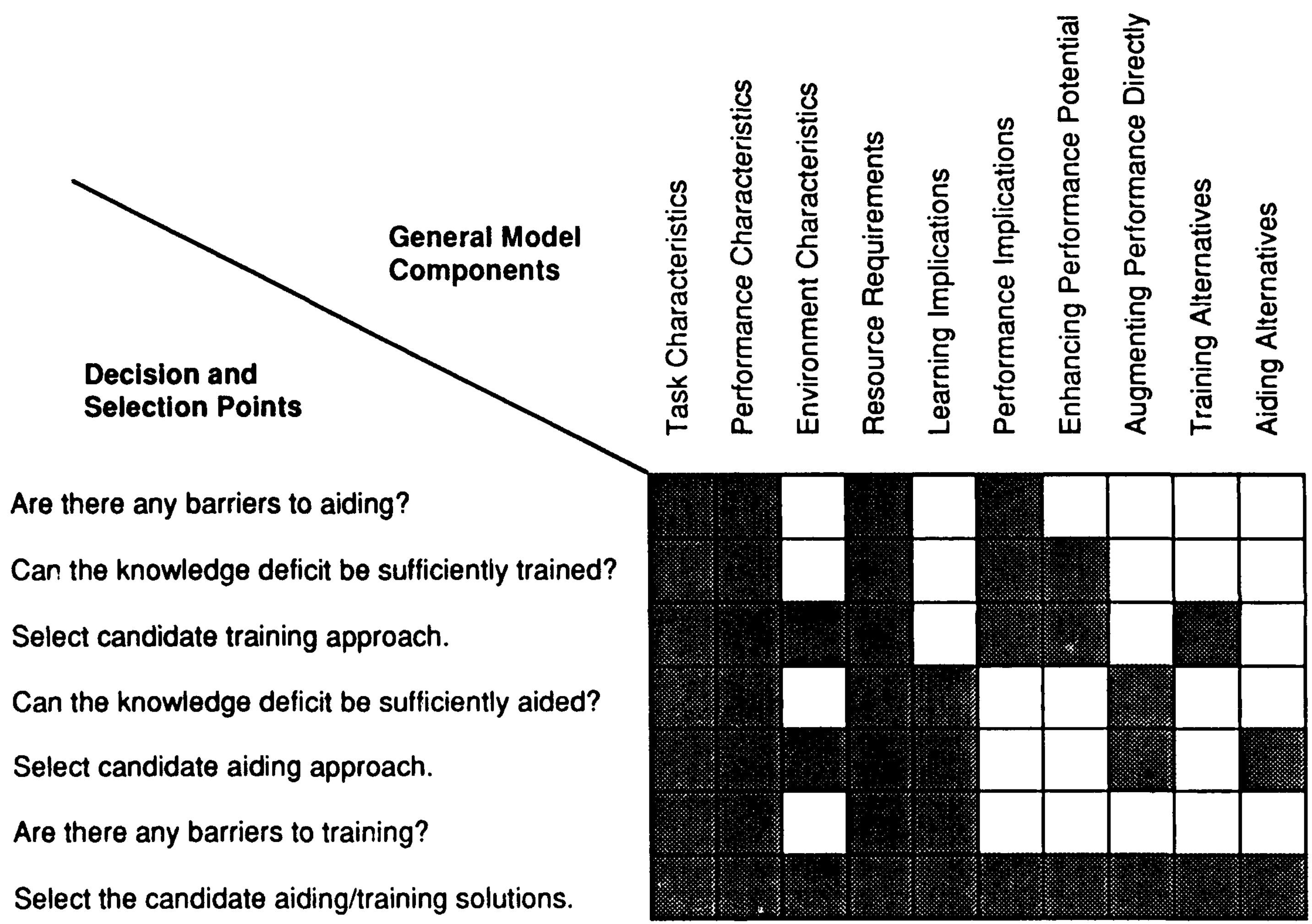
As indicated above, the general decision model is a composite of each of the individual decision points in the Knowledge Analysis and Aiding/Training Selection segment of the process structure. It is not contained in its entirety in any one decision or selection. Particular values and constructs, though, are considered indispensable components of each of these decision points. The following chart identifies those components of the general decision model which apply to each of the decision and selection points in the process model. (See Figure 12.)

While each successive decision point contains progressively more of the general decision model, this does not imply that the entire model is iteratively evaluated. Instead, the results of intermediate analyses are carried through to successive decision points. For example, determining if a knowledge deficit can be sufficiently trained implies that earlier analyses of performance implications indicated aiding, as a complete solution, to be infeasible. In some cases, however, subsequent analyses may address input factors not previously considered. For instance, while information retention requirements may not be considered among the Barriers to Aiding, they may be addressed as a potential Barrier to Training. In these cases, the necessary components of the general model must be re-activated -- at least for the new factor(s).

Level of Resolution

Implicit in the representation of the general decision model is the issue of the appropriate level of resolution of JATAT decision support. At one extreme, an A/T solution set which only includes *aid* or *train* provides insufficient detail to adequately address combinations and alternatives. The recommendations provided by such a model would be devoid of alternative aiding and training approaches. This would eliminate the potential for trade-offs and, hence, not satisfy one of the objectives of this effort. Conversely, there is little need for extreme detail (i.e., class size, course length, etc.) since such information is most useful to curriculum developers and aid designers once an A/T need has been identified.

The set of solutions shown in Figure 11 strikes a balance between these extremes by allowing for the possibility of several satisfactory combined solutions. This level of resolution of the candidate aiding methods and training environments can ; 1) provide




(Shaded areas indidcate areas of relevance from model component to decision process point.)

Figure 12. Application of General Model Components to Process Model Decision and Selection Points

useful input to other A/T models (i.e., TDS, LCOM, etc.) and related domain experts, and 2) permit the direct translation of a recommended solution to the pre-determined set of Air Force technical training locations (i.e., Residence School, Field Training Detachment, and On-the-Job).

### Supporting Networks

While this decision model can resolve A/T issues in general, it is difficult to imagine a single instantiation of this network providing A/T recommendations tailored to specific contexts. Therefore, in order to fully exploit the model's potential functionality, it is necessary to compile multiple network versions with input variables and variable relationships tailored to the context of a specific analysis.

Following this train of thought, the work accomplished to date indicates that the variables, relationships, and parameters of each networks should be dependent upon the class of task being analyzed (e.g., maintenance task analyses will differ from administrative task analyses). More specifically, the parameters (e.g., empirical values generated with a linear statistical approach) of relationships for troubleshooting maintenance tasks are likely to differ from those for the non-troubleshooting maintenance tasks. Therefore, each task type would have associated with it a network tailored via a template of corresponding variables, relationships, and parameters.

The precise representation of these networks and corresponding templates are yet to be determined. They are, however, likely to involve a mix of linear statistical models, rule-based heuristics, etc.

## JATAT PHASE 3 EMPIRICAL STUDIES

The objective of Phase 3 was to further investigate the task analysis and trade-off formulation components of the original methodology. Included in this effort was the development of a model for selecting alternative A/T approaches. The two primary foci, therefore, were the A/T decision factors which most heavily influence alternative selection and trade-off formulation, and the representations which best describe the important relationships among these factors. More specifically, during this phase of effort we pursued answers to the following factor-related questions:

- What are the important factors in an A/T decision?
- How are they operationalized?
- What do we know about the relationships among factors?
- What don't we know?

Another, equally important, issue to be resolved is the internal validity of the new JATAT model. In other words, "What is the best representation of the JATAT decision process and the relationships among the factors?" Representations gleaned from human performance studies? Linear statistical models? Or, heuristic rules?

This section describes two complementary information gathering activities designed to specifically address these questions; a statistical evaluation of expert A/T decision policies, and a series of semi-structured interviews.

## Study 1: A Statistical Evaluation of Expert Aiding/Training Decision Policies

Previous quantitative analyses of expert A/T decisions (Irvin, Blunt, and Lamb, 1988) investigated linear relationships among 13 A/T decision attributes and an expert's recommendation to aid, train, aid and train, or neither for that task. Study 1 of this effort employed a similar analytical paradigm with three modifications; a different set of 13 decision attributes were analyzed, several intermediate relationships were investigated, and a larger number of decision alternatives were evaluated.

### Decision Attributes

The decision attributes analyzed in Study 1 represent a subset of those extracted from available A/T literature. (See Appendix A.) It was apparent in this original compilation, however, that there were a large number of discrepancies (i.e., duplications, ambiguities, etc.) among the attribute nomenclatures and definitions.

Therefore, by generating nomenclature to more accurately represent the intended meanings of various attributes, and collapsing across equivalent conceptual and operational definitions, a more concise, attribute compilation was generated. (See Appendix B.) Additionally, four general A/T decision attribute categories were identified from the original literature review; the personnel, task, equipment, and environment. Therefore, in conjunction with the compilation process, each of the attributes were appropriately categorized.

Based on this work, three criteria were employed in the selection of the decision attributes to be used as dependent measures in this study. First, the attributes and corresponding definitions were to be taken directly from the compiled list. This would minimize inter-subject variability due to individual interpretations. Second, the attributes chosen must adequately represent a cross-section of the four general categories. And third, the number of attributes chosen must be sufficiently small in order to be statistically manageable. Based on these criteria, the following thirteen A/T decision attributes were selected for analysis in Study 1. (See Table 3.)

Attribute Relationships

As indicated earlier, the majority of previous aiding and training research has focused on identifying only the relationships between the decision attributes and potential A/T solutions. While quantitatively easy to analyze and interpret, this approach fails to address the more subtle complexities of these decisions in a realistic environment. Understanding the influence of the attributes on intermediate decisions within the total trade-off process is equally important to the A/T analyst responsible for performing a system evaluation. For example, "What factors (if any) prevent the use of aiding? or training?", and "If both aiding and training are applicable to the task; are either alone sufficient?". Study 1 addresses these concerns through a series of analyses intended to identify; 1) specific barriers to aiding and/or training, and 2.) attributes indicating aiding or training sufficiency for that task.

| |
|---|
| • Aptitude |
| • Experience |
| • Number of Steps |
| • Mental Skills |
| • Motor Skills |
| • Frequency |
| • Performance Rate |
| • Criticality |
| • Hazards |
| • Information Amount |
| • Number of Components |
| • Training Resources |
| • Aiding Technologies |

Table 3. List of Decision Attributes

## Expert Decision Alternatives

The majority of previous A/T research, with few exceptions (Booher, 1978), has been additionally constrained by the limited number of alternative solutions addressed. Allowing only the choice to aid, train, both, or neither eliminates the potential for various trade-offs to arise. Such a situation is in direct conflict with the stated goals of this effort. Therefore, in Study 1 the analytical investigation of the attribute-solution relationships was extended to include specific A/T approaches and techniques. (See Table 4.)

Note that the goal of this study was simply to identify those decision attributes which experts consider most influential in their aiding and training trade-off decisions. No attempt was made to quantify or qualify these relationships. The intended by-product of these investigations is a guide to more detailed research focused on determining the nature of these relationships.

| | |
|---|---|
| Aiding Approaches | Training Approaches |
| • Display Information | • Information Presentation |
| • Monitor Performance | • Modeling |
| • Assist Execution | • Coaching |
| | • Exploration |
| Aiding Techniques | |
| • Information Aid | Training Techniques |
| • Procedural Aid | • Classroom |
| • Algorithmic Aid | • Independent Study |
| • Heuristic Aid | • Simulators |
| • Assistive Aid | • On-the-Job Training |

Table 4. List of Aiding/Training Approaches and Techniques

## Subjects

There are essentially four candidate subject populations for such a study: 1) operational/field experts, 2) A/T developers, 3) A/T decision makers, and 4) A/T researchers. The A/T experiences of each population range from pragmatically oriented applications to theoretically oriented research. The goal of this effort was to focus on the more theoretic orientation, investigating the rules and heuristics employed by experts in making sound A/T decisions. The target population, therefore, were A/T researchers from the government, academia, or industry with prior Department of Defense (DoD) related A/T experience.

Seven aiding and/or training experts participated in this decision policy survey. Each of the seven subjects had a minimum of 4 years prior research experience in aiding or training related issues. All seven were civilian contractors, six of whom had been previously involved (in a contractor or government employee capacity) with A/T programs related to Department of Energy (DoE), Department of Defense (DoD), or NASA systems.

Participation in the survey was strictly voluntary and non-compensatory.

Design

In order to empirically evaluate the subjects' A/T decision policies, a series of hypothetical scenarios were employed to provide context. Each of these scenarios were generated based on select Air Force Specialties (AFSs), Occupational Survey Report (OSR) tasks, and the 13 decision attribute values. Although the A/T situations to be analyzed by the experts were hypothetical in nature, employing actual AFSs and their associated OSR tasks served two important roles. First, it provided the contextual realism necessary for the subjects to relate to the A/T issue addressed in the scenario. And second, it ensured that the expert decision policies captured directly addressed Air Force related issues.

Two AFSs chosen for this analysis: the 454X0, Jet Engine Maintenance Technician, and the 811XX, Security Police. Their selection was, to a great extent, based on the current development of other Air Force manpower and personnel modeling efforts (i.e., Advanced On-the-job Training System, Training Decisions Simulation, etc.). This selection strategy supported current Air Force emphasis on future integration of proposed manpower-personnel models.

Task selection was based on an initial pool of 48 tasks (i.e., 24 tasks from each AFS) extracted from the OSR Occupational Research Data Bank (ORDB) task listing. These tasks were selected based on task difficulty, the percentage of personnel performing the task, and on the implicit goal of selecting a representational cross-section of task types for each AFS. A 3x3 criterion table was developed by combining the high, medium, and low levels of task difficulty and percentage of personnel performing the task. Each level of task difficulty was quantitatively defined in accordance with the ORDB description (i.e., high = 6.0 and greater, medium = 4.0-5.9, and low = 3.9 and less). The corresponding values for the percentage of personnel performing the task were established through subjective analysis of the available ORDB data (i.e., high = 50-100%, medium = 25-49%, and low =10-24%). Those tasks performed by less than 10% of the AFS personnel were not considered as candidates. This decision reflected the primary concern regarding the availability of Subject Matter Expert (SME) data, and the practicality of training such a small population of personnel (training emphasis is highly correlated with the percentage of personnel performing the task). Attention was also given to selecting tasks which appropriately represented the particular AFS. This was implemented by selecting a representative sample of administration, supervision, instruction, documentation, and task performance (cognitive and motor) type tasks.

The initial list of 48 tasks was then further reduced to the final 24 based on task type; Problem Solving versus Non-Problem Solving. (Note: The decision to constrain the evaluation to a total of 24 task scenarios was based on expected time constraints.) "Problem-solving", in this study, was operationally defined as a task characteristic which requires analytic cognitive processing capabilities (i.e., requires some form of independent evaluation). In contrast, "Non-Problem Solving" tasks require more predetermined procedurally oriented behaviors. For this final winnowing process twelve (12) tasks of each type were chosen; six per AFS.

Tables 5 and 6 list the final 24 tasks utilized in this survey.

The allowable decision attribute values were operationally defined as; high, medium, low, or not applicable. This scheme provided a consistent scale across which each of the proposed tasks could be measured -- independent of specific units of measure. A complete matrix representing all possible value combinations of the thirteen decision attributes was generated, and from this matrix the 24 combinations for analysis were selected. Selection of the final 24 attribute value combinations was based on the subjective criteria of "reasonableness" and "appropriateness". The "reasonableness" criterion rejected those combinations which were intuitively unrealistic (e.g., those combinations in which all the attributes were rated high or low). The "appropriateness" criterion was directly related to the process of mapping the attribute value combinations to one of the selected tasks. More specifically, it addressed the appropriateness of the combination given the reality of the task (e.g., a

- Adjust Daily Maintenance Plans to Meet Operational Commitments (B28)
- Draft Recommendations for Changes in Equipment (B40)
- Identify Recurring Troubles on Equipment by Deficiency or Service Reports (B60)
- Evaluate Technical Order Improvement Report (C74)
- Counsel Trainees on Training Progress (D97)
- Isolate Malfunction w/ Engine System (G322)
- Annotate or Initiate AFO Form 98 (Jet Engine Afterburner Inspection Record) (E130)
- Operate Computer Automated Maintenance/ Management Systems (G350)
- Remove/Install *Safety Devices on Engine Component* (G433)
- Service Starter Units (G470)
- Test Gear-Box Carbon Seals (G473)
- Inspect Aircraft Throttle Controls for Freedom of Movement (I556)

Table 5. Jet Engine Maintenance Technicians (454X0) Tasks

- Counsel Personnel on Personal or Military-related Problems (B38)
- Plan OJT Training Programs (D156)
- Write Security Police Computer Programs (E231)
- Evaluate Situations at Incident Scenes (F275)
- Respond to Alarms (I427)
- Perform Hostage Negotiations (P578)
- Conduct Inspection of Vehicles at Installation Entry or Restricted Area Entry Points (F247)
- Employ Life-Saving Techniques (F269)
- Plot Accidents, Incidents on Maps (F304)
- Conduct Anti-Robbery Training (H345)
- Assemble or Disassemble M-16 Rifle (O542)
- Employ Individual Night Movement Techniques (Q618)

Table 6. Security Police (811XX) Tasks

combination with a high Hazard value would be inappropriate for a "Complete DD Form 1749" task).

Once the selection and mapping processes were complete a hypothetical scenario was written for each task and a task profile generated. The context of each scenario dealt with systems and/or situations analogous to those operationally existent, but was kept generic to avoid potentially confounding biases due to expert predispositions. The content validity of each scenario was then evaluated by an in-house engineer familiar with the Jet Engine Technician and Security Police domains. The task profile formed a graphical representation of the attribute value combination of each task and served as a pictorial summary of the task scenario. (See Appendix F for a series of example scenarios/profiles.)

Study 1 employed a within-subjects design; each subject responding to an eleven (11) point questionnaire (See Appendix F) for each of the 24 hypothetical A/T scenarios. The order of scenario presentation was counter-balanced by AFS (454X0 / 81XX) and task type (problem-solving / non-problem-solving). The order of the 6 tasks within each block was completely randomized.

The questionnaire was divided into three parts; aiding solution specification, training solution specification, and combined solution specification.

Three issues were addressed in both the aiding and training solution specification parts; barriers to and sufficiency of the respective solution type, and approach/ technique preference. For the two former issues, subject feedback was elicited in the form of a nominal exists or does not exist response. Approach/Technique preference, in contrast, was measured as the percentage of hypothetical resources the subject would willingly commit to employing that solution. This approach enable the subjects to employ either an "all-or-none" strategy or to recommend a combination of alternatives with a relative measure of merit.

The role of the combined solution specification part of the questionnaire was to elicit subject preference for employing the A/T approaches and techniques recommended earlier in the questionnaire. A similar resource allocation procedure was employed with aiding or training being the only alternatives.

## Procedures

Each candidate subject was contacted and given a brief explanation of the study and the estimated time requirement. Those experts indicating interest and commitment were scheduled to participate, at their convenience.

At the beginning of each scheduled evaluation, each expert was briefed on the purpose of the study, its role in the JATAT project, and the expectations of their participation (i.e., time, procedures, confidentiality). Each subject was supplied with a Task Scenario Notebook (which included all 24 task scenarios and profiles in proper presentation order and a copy of the Decision Attribute Definition Sheet) and a corresponding package of Subject Response Sheets. (See Appendix F.)

No time constraints (other than the subject's available time) were imposed on the task performance.

At least one experimenter was available during the entire test to answer any procedure-related questions.

During the post-test debrief, subjects were questioned concerning; 1.) the content validity of the task scenarios, 2.) individual decision paradigms employed, and 3.) the perceived robustness of the survey procedure for A/T decision policy capturing.

The questionnaire responses were transformed into a database format to serve as input to the statistical analyses.

## Analyses

The goal of the analysis was three-fold: identify those decision attributes which clearly influence expert selections of A/T techniques, specify linear models for making A/T decisions, and investigate trends in data for areas of future research. In order to address each of these goals, three independent statistical analyses were performed -- linear stepwise regression analyses, discriminant function analyses, and summary statistics analysis, respectively.

Each analysis was performed by subject. This eliminated confounding results due to regression toward the mean of expert decision approaches; ensuring that individual decision policies were independently addressed, intact.

The linear stepwise regression analysis of the 13 decision attributes (predictors) and recommended A/T approach and technique percentages (predicted values) was performed using a default alpha of 0.150 to enter and remove attributes from the equation. Figures 13 - 16 indicate the number of occurrences of each attribute, across experts, for a given approach or technique. Appendix D presents the direction and magnitude of the coefficient for that attribute.

Figure 13 indicates that the subjects weighted *aptitude*, *frequency*, and *training resources* most heavily in applying an Information Display approach to the task. While the *number of components* (a measure of task complexity) was most emphasized choice for Assisting Execution.

*Criticality*, *hazards*, and the *information amount* were found to be most important in the selection of an Information Aid, while *experience* and *training resources* are key in the selection of a Procedural Aid. (See Figure 14.) Additionally, *aptitude*, *frequency*, *criticality*, and *information amount* are the most heavily weighted attributes in the selection of a Heuristic Aid. Figure 14 also indicates a low level of intra-subject consistency in their applications of Algorithmic and Assistive Aids.

There is a much greater consistency among the subjects in their attribute weighting schemes in making training related decisions, as seen in Figures 15 and 16. Most notable are the emphases on *information amount* for selecting the Presentation of Information, and *performance rate*, *frequency*, and *aiding technologies* on recommending the use of Exploration as training approaches. *Motor skills* and *criticality* also manifest high consensus in the selection of a Classroom as the training technique of choice. And finally, *mental skills* and *frequency* are heavily weighted in

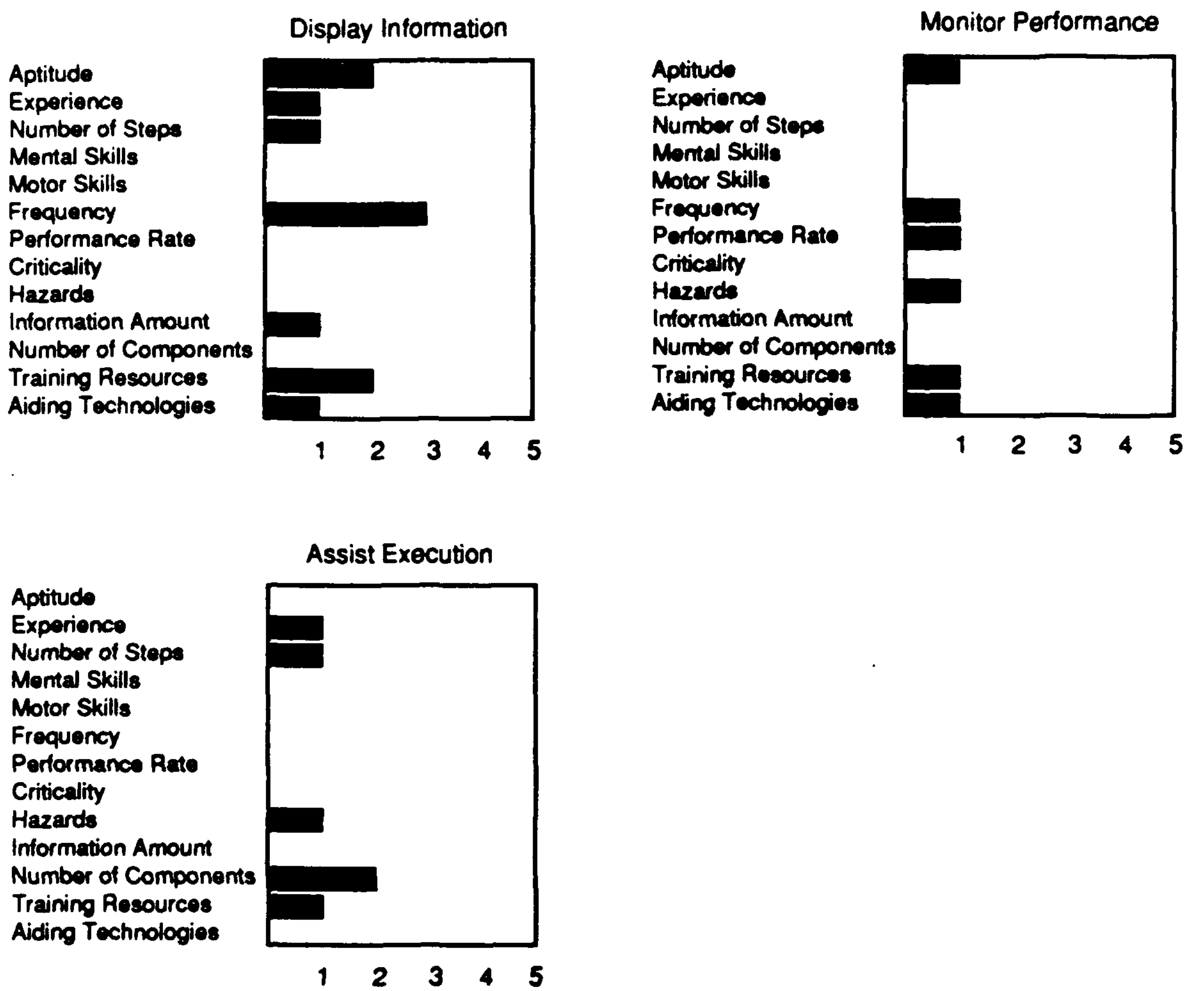



Figure 13. Summary of Sub'ect Recommendations for Aiding Approaches

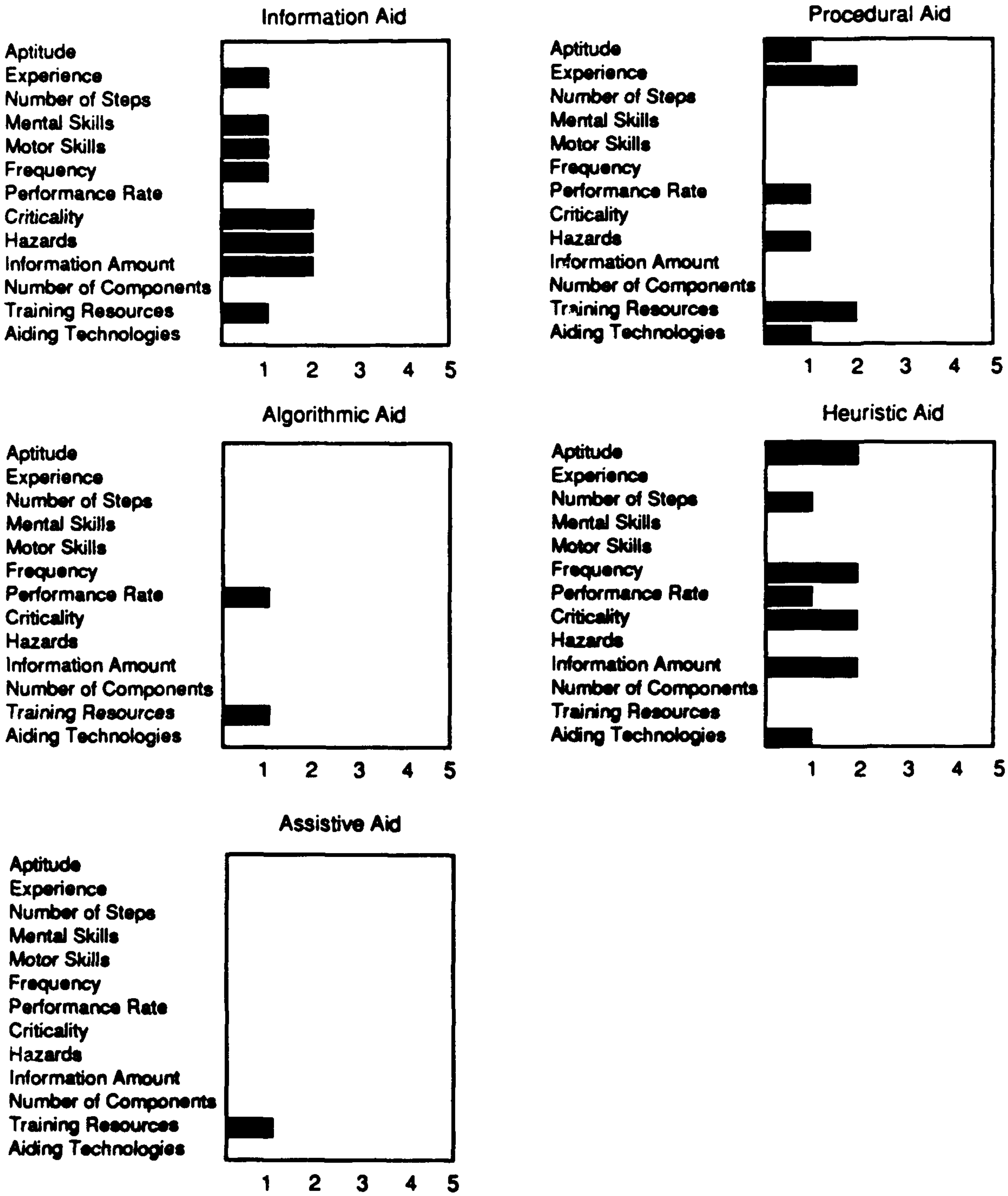



Figure 14. Summary of Subject Recommendations for Aiding Techniques

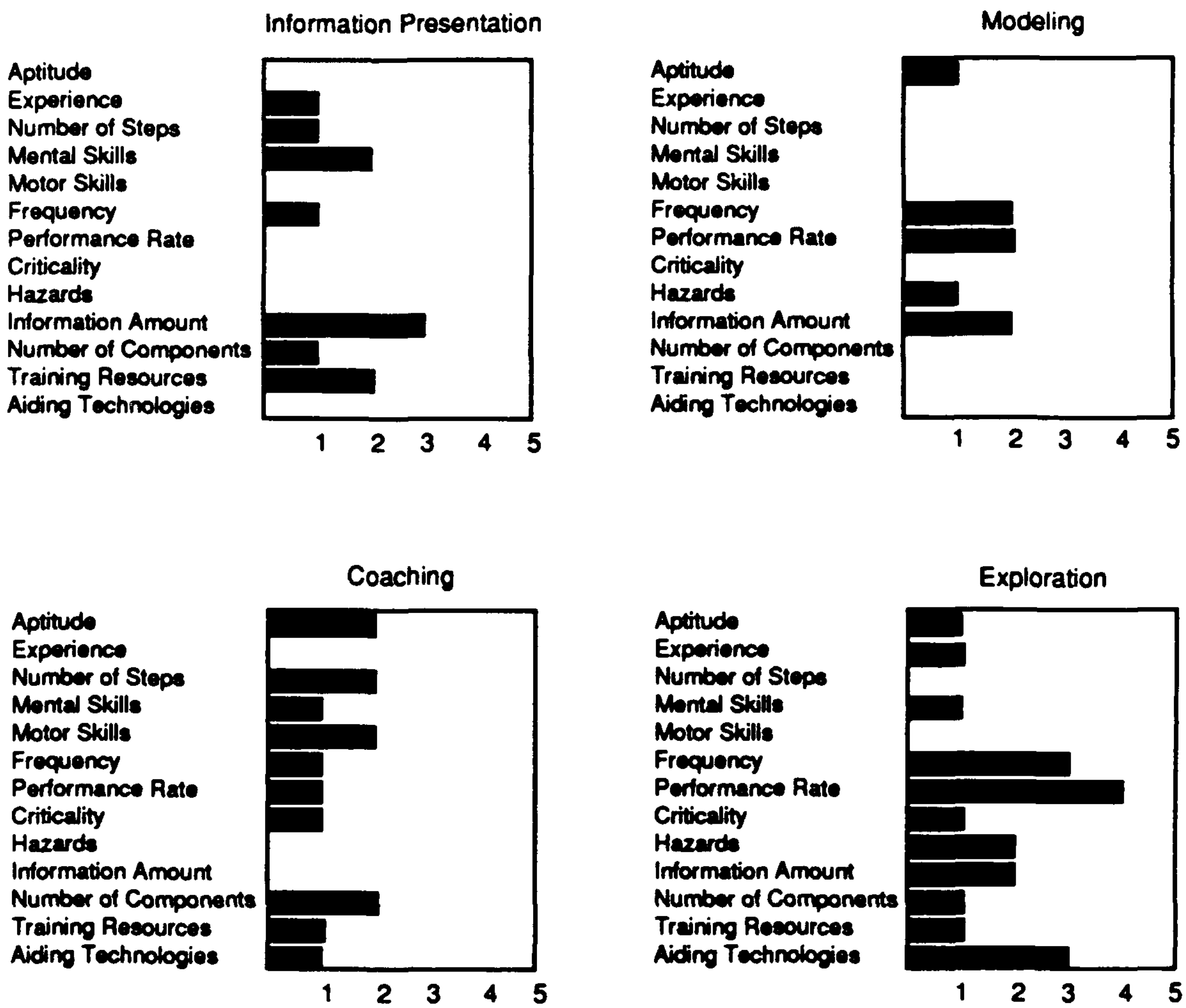



Figure 15. Summary of Subject Recommendations for Training Approaches

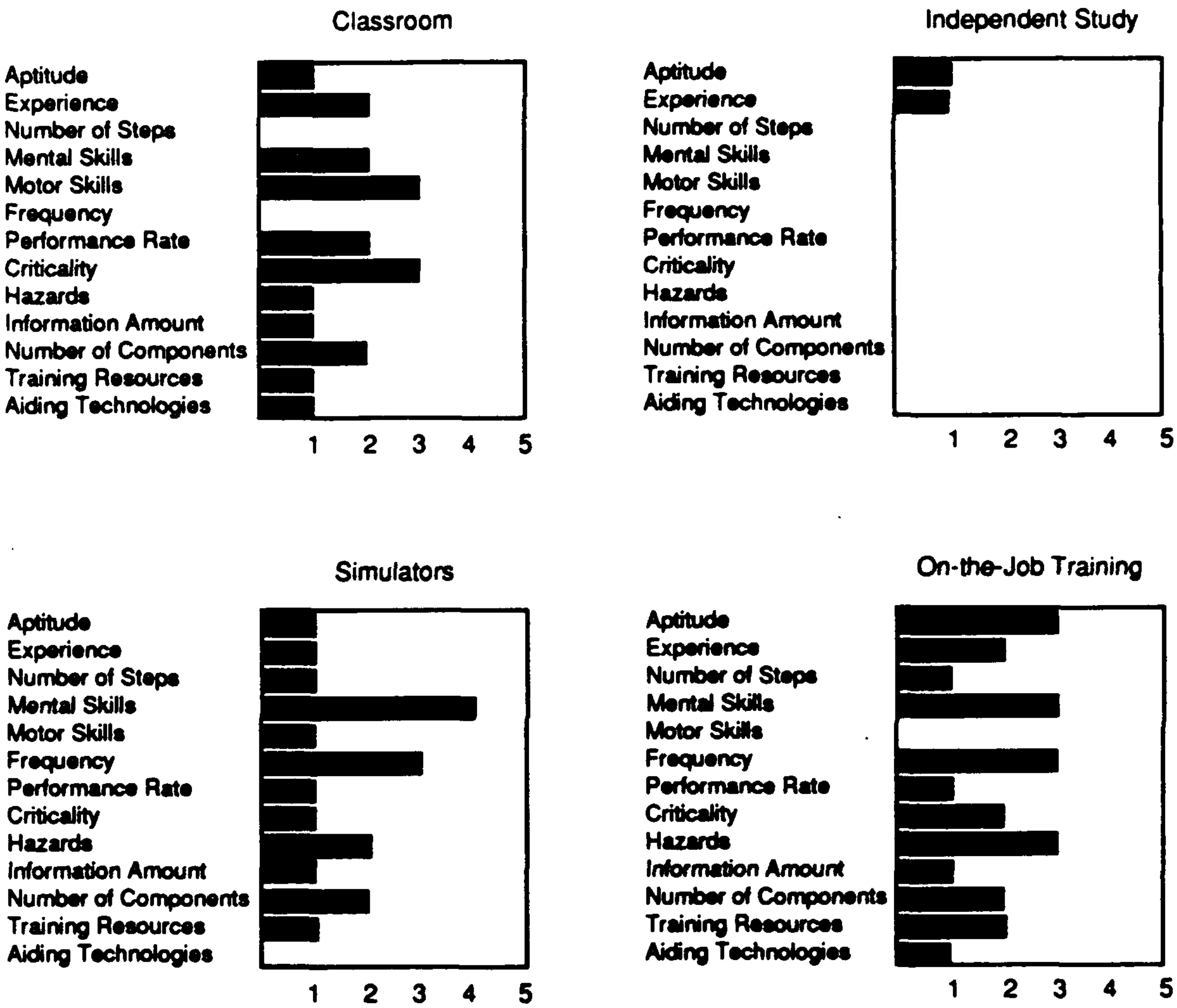



Figure 16. Summary of Subject Recommendations for Training Techniques

the decision to apply Simulators as are *aptitude*, *mental skills*, *frequency*, and *hazards* in recommending On-the-job Training.

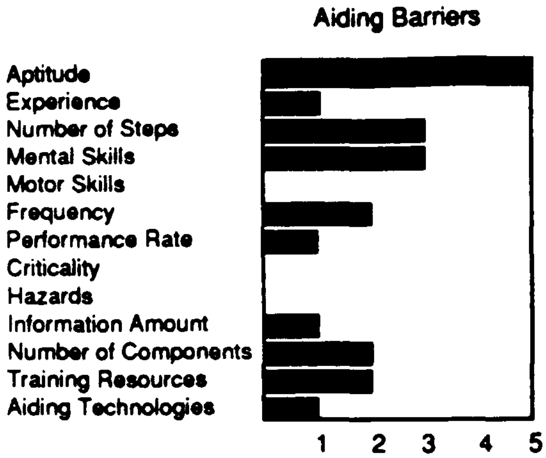
Linear discriminant function analyses were used to specify the models employed by each expert in answering the following questions; 1.) "In what conditions did barriers to either aiding or training exist ?", 2.) "In what conditions were either aiding or training alone sufficient to perform the task in question?" and, 3.) "When was a combination of aiding and training necessary?". In this case, the 13 decision attribute values again served as predictors, while barriers, sufficiency and combination now served as the predicted values. Figures 17-19 summarize, across subjects, the number of occurrences of each attribute as one of the top three weighted attributes for that model. Appendix E contains the function coefficients for each expert model.

It is clear from Figure 17 that *aptitude* dominates as the most influential attribute (followed by *number of steps* and *mental skills*) in the subjects' determination that aiding was not applicable to a specified task. Not surprisingly, *aptitude* was also influential in determining if aiding alone was sufficient for a specified task. (See Figure 18.) This was, however, moderated by consideration of *performance rate* and the *number of components*.

The determination of training sufficiency has a much greater inter- and intra-subject consistency than the determination of Barriers to Training; relative to the equivalent comparison for aiding.

Subject selection of both aiding and training as solution components placed the majority of emphasis on those attributes related to the cognitive complexity of the task (i.e., *experience*, *number of steps*, *mental skills*, and *number of components*). (See Figure 19.)

Investigation of the summary statistics, while providing less detailed information regarding specific decision models, provides the following general policy trend information.



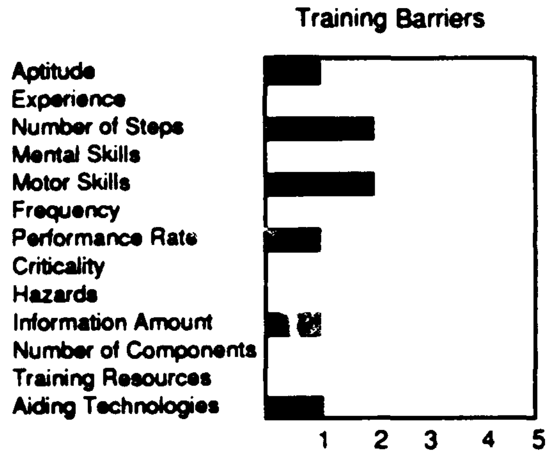
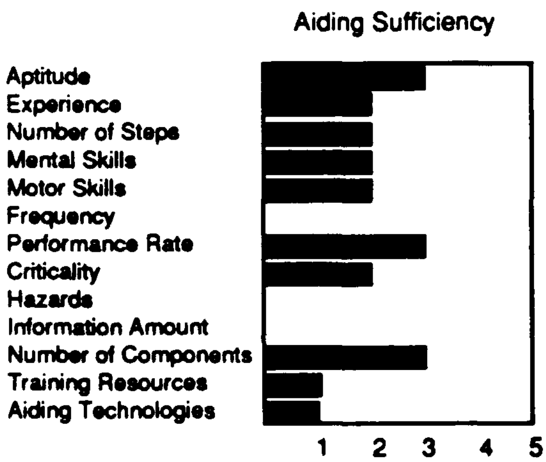




Figure 17. Summary of Subject Recommendations for Aiding/Training Barriers



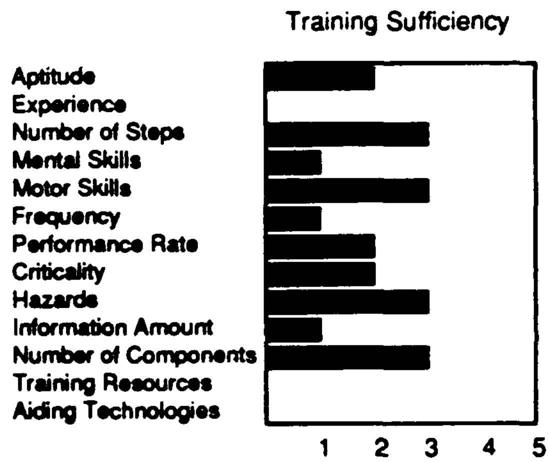




Figure 18. Summary of Subject Recommendations for Aiding/Training Sufficiency

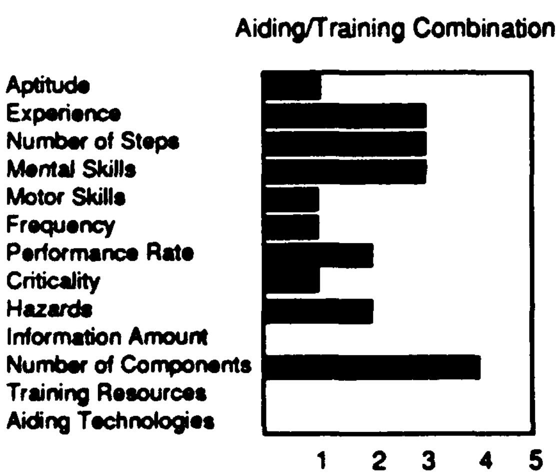



Figure 19. Summary of Subject Recommendations for Aiding/Training Combinations

In general, the more complex the aiding device the less likely subjects were to recommend its use. (See Figure 20.) Two factors potentially account for this trend: 1.) subjects employed a "simplicity first" approach (i.e., recommend the most simple device that will satisfy the requirements), and/or 2.) the tasks used in the evaluation were not sufficiently complex to warrant more sophisticated aiding devices. One exception to this trend is the increased number of recommendations to apply Heuristic Aids to Problem Solving tasks. This distinction is further accentuated by the significantly lower number of recommendations for Heuristic Aids applied to Non-Problem Solving tasks.

A similar difference exists for the application of Procedural Aids. Subjects were more likely to recommend Procedural Aids for Non-Problem Solving tasks than for Problem Solving tasks.

Figure 21 indicates that subjects were reluctant to recommend any type of individual training program (i.e., Exploration or Independent Study) regardless of task type.

Another observation from Figure 21 is that Presentation and Modeling are recommended less often for Problem Solving tasks than for Non-Problem Solving tasks. The rationale for this decision behavior may be found in the additional indication that Coaching is recommended as an approach to training Problem Solving tasks more frequently than either Presentation or Modeling. It appears that subjects tend to emphasize the need for individual operator/maintainer involvement in learning to perform in dynamic task situations.

A review of the summary statistics in Tables 7 - 14 substantiate the earlier decision to analyze each subject's decision model independently due to expected differences in A/T decision approaches. For instance, Subjects 2 and 4 were much more training oriented; recommending far fewer aiding applications relative to other subjects. Subject 2 was particularly unique in that they recommended the use of Exploration and Independent Study significantly more than any other subject. While Subjects 1,3, and 5 relied heavily on the use of Information Aids, Classroom instruction, and On-the-

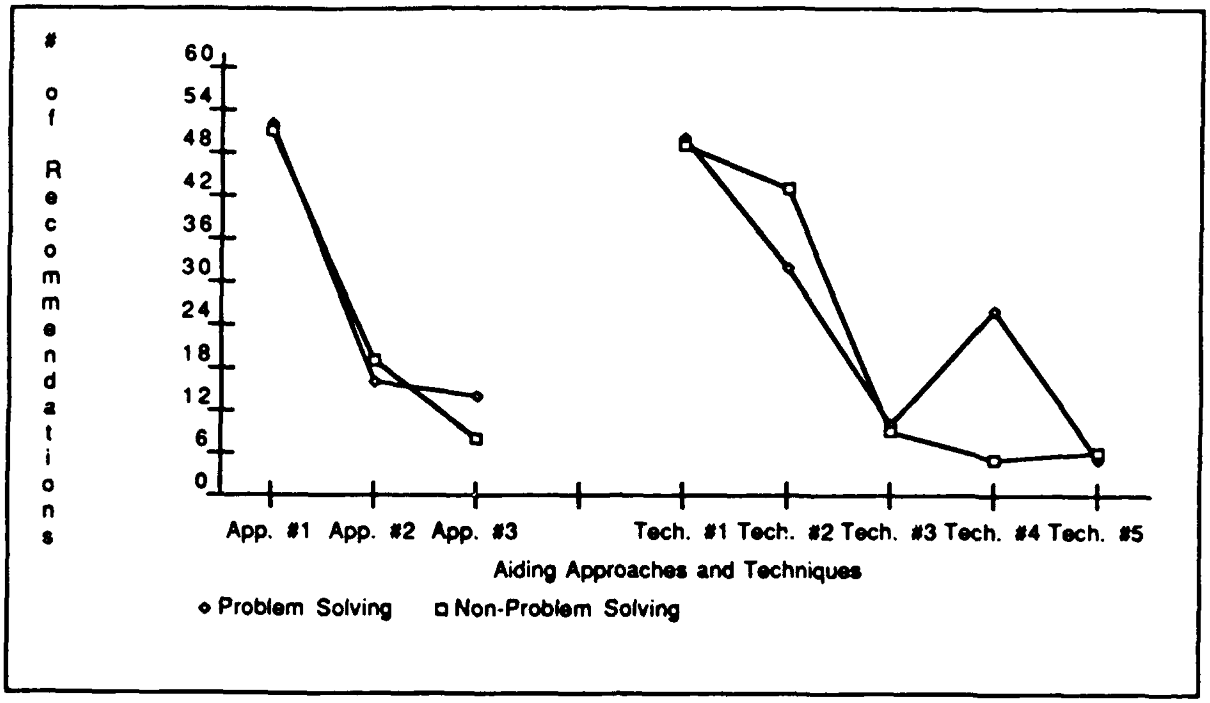



Figure 20. Summary Statistics: Subject Recommendations of Aiding Approaches and Techniques

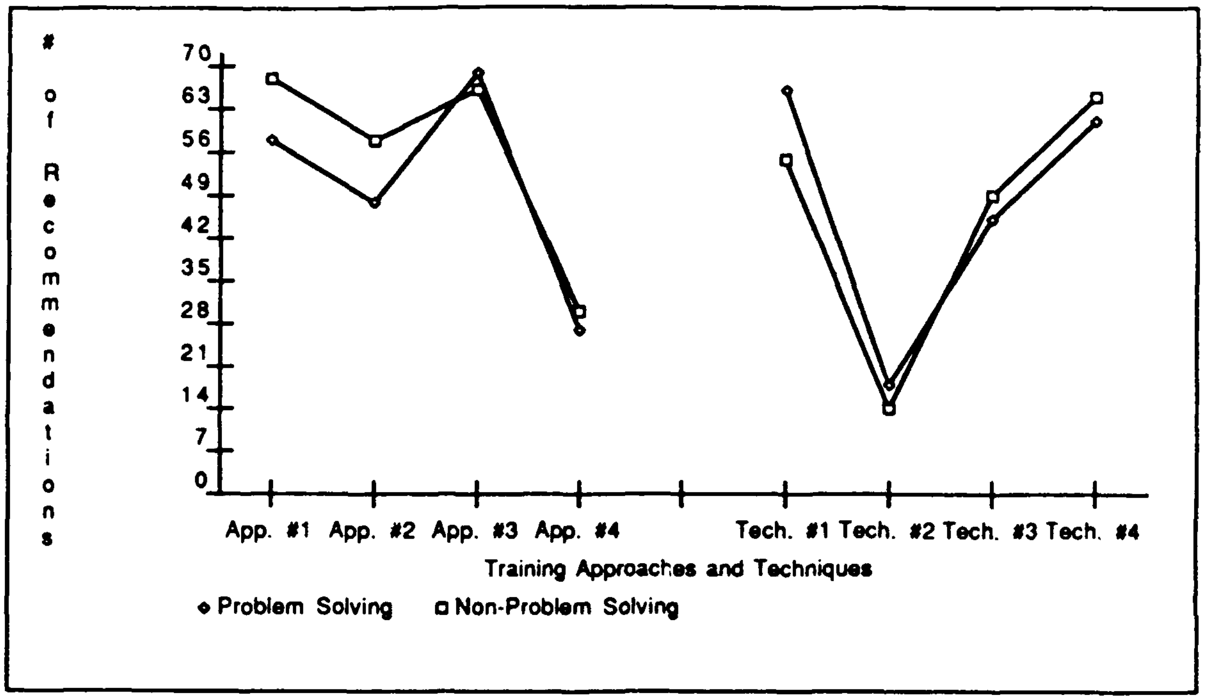



Figure 21. Summary Statistics: Subject Recommendations of Training Approaches and Techniques

| Aiding Approaches | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Display Information | | | | | | | |
| N of Cases | 11 | 3 | 10 | 2 | 7 | 9 | 10 |
| Mean | 86.636 | 63.333 | 90 | 31.5 | 100 | 90 | 77 |
| Monitor Performance | | | | | | | |
| N of Cases | 2 | 4 | 3 | 1 | 0 | 2 | 4 |
| Mean | 26.5 | 77.5 | 26.667 | 33 | . | 45 | 22.5 |
| Assist Execution | | | | | | | |
| N of Cases | 3 | 2 | 1 | 3 | 0 | 0 | 5 |
| Mean | 31 | 100 | 20 | 67.667 | . | . | 28 |

Table 7. Summary Data for Aiding Approaches by Subject -- Problem Solving Tasks

| Aiding Techniques | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Information Aids | | | | | | | |
| N of Cases | 11 | 4 | 9 | 2 | 7 | 8 | 9 |
| Mean | 40.727 | 42.5 | 44.444 | 15 | 37.857 | 56.25 | 50 |
| Procedural Aids | | | | | | | |
| N of Cases | 9 | 6 | 8 | 1 | 5 | 0 | 3 |
| Mean | 56.111 | 66.667 | 45 | 10 | 87 | . | 26.667 |
| Algorithmic Aids | | | | | | | |
| N of Cases | 3 | 0 | 4 | 3 | 0 | 0 | 0 |
| Mean | 37.667 | . | 27.5 | 63.333 | . | . | . |
| Heuristic Aids | | | | | | | |
| N of Cases | 1 | 2 | 5 | 2 | 1 | 8 | 7 |
| Mean | 33 | 65 | 46 | 35 | 50 | 56.25 | 54.286 |
| Assistive Aids | | | | | | | |
| N of Cases | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| Mean | . | . | . | . | . | . | 18 |

Table 8. Summary Data for Aiding Techniques by Subject -- Problem Solving Tasks

| Training Approaches | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Presentation | | | | | | | |
| N of Cases | 12 | 6 | 12 | 10 | 9 | 9 | 9 |
| Mean | 29.75 | 20 | 34.167 | 29 | 33.333 | 24.444 | 28.333 |
| Modeling | | | | | | | |
| N of Cases | 10 | 7 | 6 | 5 | 5 | 8 | 7 |
| Mean | 36 | 37.143 | 26.667 | 26.6 | 33 | 33.75 | 35.714 |
| Coaching | | | | | | | |
| N of Cases | 11 | 12 | 11 | 12 | 11 | 7 | 10 |
| Mean | 40.273 | 33.333 | 48.182 | 61.917 | 47.727 | 47.143 | 44 |
| Exploration | | | | | | | |
| N of Cases | 1 | 12 | 3 | 1 | 3 | 2 | 5 |
| Mean | 40 | 35 | 33.333 | 33 | 36.667 | 40 | 61 |

Table 9. Summary Data for Training Approaches by Subject -- Problem Solving Tasks

| Training Techniques | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Classroom | | | | | | | |
| N of Cases | 12 | 6 | 12 | 11 | 10 | 7 | 8 |
| Mean | 15 | 16.667 | 24.167 | 30.909 | 33 | 35.714 | 25 |
| Independent Study | | | | | | | |
| N of Cases | 2 | 8 | 1 | 2 | 1 | 3 | 1 |
| Mean | 20 | 25 | 50 | 15 | 30 | 50 | 10 |
| Simulators | | | | | | | |
| N of Cases | 6 | 6 | 6 | 7 | 5 | 4 | 11 |
| Mean | 35 | 28.333 | 31.667 | 42.857 | 36 | 75 | 69.091 |
| Job Experience | | | | | | | |
| N of Cases | 12 | 12 | 11 | 9 | 10 | 4 | 3 |
| Mean | 64.167 | 61.667 | 60.909 | 58.889 | 56 | 50 | 46.667 |

Table 10. Summary Data for Training Techniques by Subject -- Problem Solving Tasks

| Aiding Approaches | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Display Information | | | | | | | |
| N of Cases | 11 | 5 | 11 | 2 | 8 | 7 | 7 |
| Mean | 80.602 | 52 | 85.455 | 46.5 | 90 | 88.571 | 82.857 |
| Monitor Performance | | | | | | | |
| N of Cases | 1 | 5 | 5 | 1 | 1 | 2 | 4 |
| Mean | 20 | 80 | 32 | 33 | 60 | 40 | 30 |
| Assist Execution | | | | | | | |
| N of Cases | 3 | 2 | 0 | 2 | 1 | 0 | 0 |
| Mean | 63.333 | 70 | 0 | 36.5 | 20 | 0 | 0 |

Table 11. Summary Data for Aiding Approaches by Subject -- Non-Problem Solving Tasks

| Aiding Techniques | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Information Aids | | | | | | | |
| N of Cases | 11 | 6 | 10 | 2 | 8 | 6 | 6 |
| Mean | 19.545 | 50 | 34 | 60 | 26.875 | 45 | 20 |
| Procedural Aids | | | | | | | |
| N of Cases | 11 | 5 | 10 | 1 | 8 | 3 | 6 |
| Mean | 67.727 | 84 | 65 | 20 | 70.625 | 60 | 68.333 |
| Algorithmic Aids | | | | | | | |
| N of Cases | 0 | 1 | 4 | 1 | 1 | 1 | 1 |
| Mean | 0 | 30 | 27.5 | 20 | 20 | 50 | 100 |
| Heuristic Aids | | | | | | | |
| N of Cases | 0 | 0 | 0 | 1 | 0 | 3 | 1 |
| Mean | 0 | 0 | 0 | 20 | 0 | 66.667 | 40 |
| Assistive Aids | | | | | | | |
| N of Cases | 3 | 1 | 0 | 1 | 0 | 0 | 1 |
| Mean | 46.667 | 50 | 0 | 20 | 0 | 0 | 30 |

Table 12. Summary Data for Aiding Techniques by Subject -- Non-Problem Solving Tasks

| Training Approaches | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Presentation | | | | | | | |
| N of Cases | 12 | 8 | 10 | 9 | 10 | 12 | 7 |
| Mean | 36.667 | 27.5 | 24 | 36.667 | 31 | 19.583 | 25 |
| Modeling | | | | | | | |
| N of Cases | 12 | 8 | 10 | 0 | 10 | 10 | 8 |
| Mean | 25.833 | 42.5 | 37 | 0 | 44 | 25 | 30 |
| Coaching | | | | | | | |
| N of Cases | 12 | 3 | 11 | 9 | 11 | 10 | 10 |
| Mean | 32.5 | 23.333 | 47.273 | 63.333 | 33.636 | 40 | 52 |
| Exploration | | | | | | | |
| N of Cases | 2 | 10 | 2 | 2 | 3 | 7 | 4 |
| Mean | 30 | 47 | 35 | 100 | 26.667 | 45 | 66.25 |

Table 13. Summary Data for Training Approaches by Subject -- Non-Problem Solving Tasks

| Training Techniques | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Classroom | | | | | | | |
| N of Cases | 11 | 4 | 10 | 9 | 11 | 5 | 5 |
| Mean | 18.182 | 20 | 22 | 46.667 | 26.364 | 10 | 16 |
| Independent Study | | | | | | | |
| N of Cases | 1 | 5 | 1 | 0 | 2 | 3 | 2 |
| Mean | 60 | 32 | 50 | 0 | 40 | 45 | 45 |
| Simulators | | | | | | | |
| N of Cases | 8 | 6 | 7 | 6 | 9 | 6 | 7 |
| Mean | 33.75 | 33.333 | 32.856 | 40 | 68.889 | 61.667 | 61.429 |
| Job Experience | | | | | | | |
| N of Cases | 12 | 11 | 12 | 7 | 7 | 9 | 7 |
| Mean | 55.883 | 60 | 60 | 62.857 | 30 | 71.667 | 85.714 |

Table 14. Summary Data for Training Techniques by Subject -- Non-Problem Solving Tasks

Job Training, Subjects 6 and 7 recommended a more uniform application of the various A/T techniques.

As stated earlier, the goal of these analyses was to identify significant trends and relationships in the A/T decision models employed by the 7 participants. The pursuit of quantifying or qualifying these observations is left to future research efforts.

Post-Test Debriefs

Validity of Scenarios -- During the post-test debriefs, all subjects indicated that the task scenarios and profiles were understandable and reasonable.

Expert Decision-Making Paradigms -- Differences in expert decision-making approaches were elicited through informal discussions in which the subjects attempted to verbally recall the rationale employed in making several of the evaluation decisions.

The responses indicate that while some experts employ a more performance-based approach (addressing constraints only after all the solution alternatives have been identified), others clearly rely more heavily on identifying the subset of reasonable solutions and determining which of those satisfy the requirements (a constraint-based approach). Experts employing a performance-based approach emphasized the influence of the personnel, task, and equipment attributes. In contrast, those experts employing a constraint-based approach spoke mostly of solution technologies and available resources.

There was considerable intra-subject variability regarding the sufficiency of the information available to make the decision. For some tasks, it was felt that certain attributes were not necessary to make an A/T decision and that the available information was more than sufficient. However, the converse was equally true. It is unclear whether this variation is due to inconsistencies in the rationale used by the expert, or due to differences among the tasks. In any case, it is clearly better to err on the side of too much detail that too little.

Robustness of the Analysis -- Additional expert input, spawned by these discussions, indicated that a linear statistical analysis of multiple selection responses is too constrained as an approach for thoroughly investigating the dynamic A/T decision environment.

Surprisingly, when early pilot-test evaluations included questions regarding *intermediate decision constructs* (e.g., *cognitive resource loading and* learning/performance implications), subjects indicated difficulty responding to the questionnaire. In support of their feedback, they cited a resistance to framing their decision processes in pre-specified terminology. (These questions were subsequently removed from the remaining questionnaires.)

However, post-test subjective feedback indicated that such constructs would have been useful as post-decision analysis measures. In other words, intermediate constructs do play a subtle role in making such decisions but it is easier to investigate their impact after the decision has been made.

## Study 2. Informal Investigation of the Content/Construct Validity of the JATAT Model

As earlier stated, one objective of this phase of the JATAT project was to perform an informal investigation of the internal validity of the hybrid A/T decision model. More specifically, the purpose of this investigation was to determine if, at a general level, the content of the JATAT model covers a representative sample of the A/T decision domain (content validity) and if it adequately addresses the theoretical constructs of an A/T decision support system (construct validity).

Several candidate approaches exist as means for pursuing this investigation; predictive, model-based evaluations, historical analyses of previous successes/failures, and subjective evaluations by A/T experts. Each of these vary in their required level of effort and their empirical rigor.

The approach to be chosen for this effort was subject to several important constraints, primarily; limited time and resources, and the relative immaturity of the model. Simply stated, the time and resources required to perform a predictive, model-based approach were well beyond the scope of this effort. This method would entail conducting an exhaustive search of current Air Force systems to identify a potential A/T deficiency, generating a recommended solution with the JATAT model, and authorizing, implementing and evaluating the resultant performance of that recommendation. A historical analysis of previous aiding and training successes/failures would have suffered from the same time and resource limitation. Additionally, it would potentially lack the necessary decision attributes values and adequate performance measures. In either case, the current JATAT model, while structurally complete, lacks the detail (i.e., quantitative/qualitative relationships among intermediate constructs) necessary to independently arrive at specific answers to specific problems.

Subjective expert evaluation through informal interviews, in contrast, provides an expeditious method to investigate, in a general sense, the expected inputs and outputs of the JATAT model against previous experience. This approach, in particular, enables subjective validation of what does exist as well as feedback regarding perceived deficiencies in the current model.

Therefore, Study 2 was performed using a series of informal, semi-structured interviews with available A/T experts.

Subjects

Eight experts from academia, industry and the DoD participated in this portion of the study. None of the subjects participating in Study 2 had participated in the earlier statistical survey. Again, all subjects had prior experience in government-related aiding and/or training projects and all subject participation was voluntary and without compensation.

## Procedures

Each candidate subject was first contacted through a preliminary screening call. During this call, the purpose of the interview was briefly described and the expert's level of interest for acting as a participant was elicited.

A follow-up contact was later made with each interested candidate. The purpose of this call was to address, in more detail, the goals of the interview process, expected time requirements and scheduling constraints. Since each subject was participating on a volunteer, non-compensatory basis, the interview sessions were limited to one hour in length. Those candidates who displayed continued interest and availability were scheduled for an interview at a time convenient to both them and the experimenters.

Each scheduled expert was sent an interview packet which contained an introductory letter, a list of decision attribute definitions, four task scenario/profile combinations, and a summary page of A/T decision questions. The task scenario/profiles and attribute definitions were taken directly from the task scenario notebook used in Study 1. (See Appendix F.) The A/T decision questions were compiled from the questionnaires also employed in Study 1. The purpose of this packet was to familiarize each expert with the scope and focus of the current JATAT effort and the expectations of them as participants, prior to the interview.

Each interview followed a pre-determined protocol. This included an introduction to JATAT and to the expert, a review of current A/T decision-making and related issues, discussions of alternative approaches, and a critical evaluation of the current JATAT model.

During the introduction, the experts were given a brief overview of the JATAT project; the sponsor, the history, the goals, and, again, the objectives of the interview session.

Each expert, in turn, gave a short dissertation of their experiences and approach to aiding or training decision-making. This review of each experts' recent experiences with aiding and/or training decision efforts played two important roles. One, it provided the experimenters with exemplary detail allowing them to more clearly understand the experts' decision-making approach. And two, it aided the experts in becoming more actively involved with the interview atmosphere. (Note: the task scenarios included in the familiarization packet were to be used as mental triggers, or sources of discussion, if necessary, during this time.)

The interviewers then promoted more in depth discussions of the general constructs and approaches employed by the expert in their example. This led to further discussions of the limitations of current approaches and identification of viable alternatives.

Finally, the current JATAT decision aiding model was presented allowing the expert to critically evaluate its strengths and weaknesses.

## Summary of Responses

In review, the purpose of the interview activities was to elicit expert opinion regarding perceived content/construct validity of the current JATAT decision aiding model. Therefore, in order to most thoroughly present the expert responses, this section has been divided into three major portions, each of which presents a compilation of the issues addressed by the interviewees. The first portion presents two strategic issues associated with future JATAT development. The second, presents feedback supporting the current model. And the third, presents feedback identifying its deficiencies.

## Strategic Issues

Even from among the wide variety of expert aiding and training backgrounds, two issues were nearly unanimously addressed and nearly complete consensus was attained.

First, the development of a decision support system with goals and objectives similar to the current JATAT effort would be of great value to the aiding and training decision-making communities. Pursuit of such a system is imperative.

And second, a clear and distinct identification of the intended user population is essential to the development of such a system. As with any new system, an ill-defined or imprecise definition of the user community and its needs endangers the potential success of such a system at its very out-set. Therefore, in situations in which no distinct user populace currently exists, as is the case with JATAT, it is imperative that the support requirements of related user communities be identified and addressed by the proposed system. Several experts recommended that Air Force Special Programs Office (SPO) personnel, Army Training-Doctrine (TRADOC) Command, Combat/Training Development School personnel, Human Resources department personnel and their military and civilian counterparts potentially represent such user populations.

Support for the Current Model

The Use of Task Analyses -- During the discussions of current A/T decision processes, experts indicated that, too frequently, A/T decision solutions are reactive in nature and driven by technology. More specifically, customers often bias an analyst's investigation toward a particular solution without thoroughly understanding the requirements of the problem. A typical question is, "Can we use this (some specific) technology?" Unfortunately, the evaluation of the recommended solution is often equally reactive; following the same constraint-based pattern. ("Why didn't we use this technology?")

A constraint driven approach, as such, is highly susceptible to fluctuations in external factors (i.e., technology, leadership, organizational policy, etc.). Therefore, in order to assist an analyst in taking a more proactive approach to generating and evaluating recommended A/T alternatives a decision support system must be requirements driven.

As in JATAT, this approach requires a thorough task analysis upon which alternative recommendations are based. Once a viable subset of requirements based solutions are formulated, final recommendations can then be altered in response to fluctuations in external constraints. In this way, external constraints will exhibit much less impact on the overall decision process.

The Use of Intermediate Explanations -- In order for a decision support/advisory system to be useful, the user must have enough confidence in the system's recommendations to use it.

One important factor contributing to human-machine confidence is an understanding of the decision model employed by the system. In situations in which the user's solution and the system's recommendation conflicts, the user must assume the role of decision arbitrator. In this capacity, having access to the intermediate decisions arrived at by the system enables the user to modify his interpretation and accept the system's recommendation, or reject the system's recommendation in favor of his original solution. In the absence of such intermediate explanations, the latter decision is simply made most frequently. In other words, users have inherently low confidence in systems which accept a problem definition as the input and provide only a solution as the output. Therefore, the most important component of an advisory system is the critic -- that which provides intermediate explanations throughout the decision process.

By including intermediate decision constructs as integral components of the JATAT model, a subsequent decision support system would be capable of providing the intermediate explanations on inquiry.

The Use of Simulation-Based Analyses -- Several experts suggest that in order for a recommendation to be considered reliable, it must be accompanied by supporting performance data. While the scope of this phase of the JATAT effort has focused solely on the model for formulating aiding and training alternatives, it is clear that the simulation-based evaluation component of the Phase 2 hybrid model has considerable merit.

Deficiencies of the Current Model

There were essentially two deficiencies with the current JATAT model identified by the interviewed experts. First, the attribute categories addressed (personnel, task, equipment, and environment) in the model do not reflect organizational influences. Although difficult to quantify, and sometimes more difficult to define, organizational issues have a significant impact on many A/T decisions. And second, the personnel attributes analyzed (aptitude, experience) do not address specific capabilities and experiences of the individual. While this issue is addressed at the task level in the process support structure ("Are the activities trained or aided in another AFS?") a more direct approach to capabilities with respect to A/T technologies is certainly appropriate (i.e., "Have the personnel had any experience with computer based training?").

## SUMMARY

The objective of this phase of effort has been to further investigate the task analysis and trade-off formulation components of the original JATAT methodology. An integral component in this effort was to be the development of a conceptual model for selecting alternative A/T techniques for a given task. In support of this development, two independent evaluations were to occur; the first, a statistical analysis of the decision attributes which contribute to the A/T decision process, and the second, an informal investigation of the internal validity of the newly formulated model.

During the past year, these efforts have achieved several important milestones toward the eventual implementation of a complete JATAT Decision Support System. First, the JATAT General Decision Model was formulated. This model responded to the deficiencies of earlier approaches by: 1.) addressing a larger array of aiding and training alternatives, 2.) investigating a new complement of attribute-solution relationships through the inclusion of important intermediate decision constructs, and 3.) addressing specific operationally oriented inputs. Pursuit of this latter component resulted in the development of the Process Support Structure which provides the operational context necessary to the General Decision Model based on currently available Air Force data structures (i.e., ORDB, OSR Task Analyses, etc.). A statistical survey of 7 A/T experts' decision policies resulted in a series of initial observations regarding specific attribute-solution relationships which will provide guidance for future research efforts directed at quantifying/qualifying those relationships. And finally, a series of semi-structured interviews with other A/T experts to informally validate the structure and methodology of the JATAT model provided strong, positive support for the current direction of the JATAT program.

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## APPENDIX A

Compilation of Job Aiding/ Training Attributes.

- A literature review of the attributes used in job aiding/training trade-off decisions was conducted which resulted in the following compilation.

- Only the enumerated attributes within each article were included in the compilation.

- The following bullets identify some of our findings based on this review of the literature:

  - There are many attributes which have been addressed in the literature, some of which have multiple labels and/or multiple definitions.
  - Some attributes are defined without specific recommendations, while some are never clearly defined at all.
  - Other authors are content to make recommendations without clearly defining the attributes.
  - Very little of the literature presents specific equations or algorithms for relating the many attributes.

- It is clear, from this compilation, that there is currently no comprehensive research which accounts for all of the attributes.

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Booher (1978) | task type | troubleshooting | Test equipment setup, operation, alignment-adjustment procedures, fault isolation, signal tracking, remove-replace failed component. | |
| | task type | non-troubleshooting | Operator tasks, preventive inspection, maintenance, servicing, simple repairs, disassembly, assembly, remove-install, calibration. | |
| | technician aptitude | low | Functional literacy (5th grade) and spatial ability of minimum level for operator or maintenance activities; for example, at least 40 but not 45 on GCT,ARI, and MECH tests. | This level has low probability of ever doing more than non-trouble-shooting type of maintenance. |
| | technician aptitude | mid | 9th grade reading level or above. Score between 45 and 60 on GCT, ARI, MECH tests. | Sufficient aptitude to do non-trouble-shooting maintenance and operator activities with partially proceduralized JPA; sufficient aptitude to do troubleshooting with FPJPA. |
| | technician aptitude | mid-high | | Sufficient aptitude to progress in careers with experience and use of JPAs. Should be able to reach level of high-level technician in 3 to 4 years, where troubleshooting can be done with deductive aids only. |
| | technician aptitude | high | Score 60 or better on GCT, ARI, MECH tests. | Sufficient to do non-trouble-shooting and operator tasks on given types of equipment with minimum directions and some system-specific OJT. Can do troubleshooting with FPJPA. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Booher (1978) | technician experience | low | 0-6 months of actual on-job experience. | |
| | technician experience | mid | 6-12 months of actual on-job experience in specific equipments; 1-2 years of job experience on varied equipment types, but no theory. | |
| | technician experience | high | More than 1 yr. on specific equipment; 2-4 yrs. of varied experience across equipment types, having had classroom theory, with special training in use of deductive aids. | |
| | equipment complexity | low, mid-high | Equipment complexity is primarily a function of how many pieces or parts are required to make it operate reliably. Complexity may vary depending on the type of equipment (eg. electrical, mechanical, digital electronics). | |
| | task complexity | low, low-mid, mid-high,high | Task complexity varies with maintenance philosophy, task frequency, and task difficulty (eg. requiring precision motor skills, coordination of interdependent tolerance, or alternative forms of accomplishing the action). | |
| Bullock (1982) | rapid performance | | | Using a job aid may slow the performance unacceptably. |
| | frequent performance | | | Using a job aid may be cumbersome or unnecessary for a frequent performance. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Bullock (1982) | simple performance | | | May also make use of job aids cumbersome or unnecessary, although the possibility of forgetting due to infrequent performance must always be considered. |
| | variable performance | | | May require greater flexibility of performance than can be realized via job aid guidance. |
| | physical barrier | | | The nature of the work or its environment may make it unacceptably cumbersome or physically impossible or risky to use job aids, for example, an alarm investigator searching a dark building for a possible intruder. |
| | psychosocial barrier | | | In some situations there can be a concern that a job aid may hamper effective interactions with others involved in the job performance,... |
| Goins et al. (1989) | task criticality | critical, not critical | Task criticality, which is a measure of the importance of performing the task in meeting the goal. | |
| | task newness | not used in model | Task newness, which is the determination of whether or not the student has previous experience in learning how to do the task or in task performance on the job. | |
| | personnel hazards | exists, doesn't exist | Personnel hazards which identify tasks that, if improperly performed, can cause injury or death to the performer or others. | |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Goins et al. (1989) | equipment hazards | exists, doesn't exist | Equipment hazards, which identify tasks that, if improperly performed, can cause minor hardware damage or major damage to abort the mission. | |
| | new skills or knowledge | required, not required | New skills or knowledge required to perform the task. | |
| | task frequency | > 3 months, < 3 months | Task frequency, which identifies performances that are frequent enough so that the student will not forget what to do between learning the task and performing that task on the job for the first time. | |
| | task length | 1-3 steps | | Short simple tasks consisting of 3 subtasks or less (procedural steps) do not require refresher training earlier than 6 months after learning. After 6 months, job performance aids should suffice for refresher training. |
| | task length | 4-9 steps | | More complex tasks consisting of 4-9 subtasks do not require refresher training earlier than 3 months after learning. Between 3-6 months, either refresher training or job performance aids should be adequate to maintain proficiency. |
| | task length | 10-14 steps | | Longer tasks consisting of 10-14 subtasks may require job performance aids, refresher training, or both 3 months and 6 months after learning. Refresher training is required 1 year later. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Goins et al. (1989) | task length | 15 or more steps | | A task consisting of 15 or more subtasks, the most complex task considered, may require a job performance aid after only 3 months. Refresher training is required for a longer period of time. |
| Harless (1986) | performance frequency | low | A task performed once a year is certainly characterized as infrequent. A task performed every day is probably not low frequency. | A job task that is performed with relatively low frequency is a good candidate for aiding. |
| | task complexity | high | A task containing numerous steps (complex because of quantity) is more complex than a task of few steps. The task is qualitatively complex when fine discrimination of stimuli is involved, or recognition of stimuli belonging to the same class, or ... | A job task that is considered highly complex is a good candidate for aiding. |
| | task criticality | high | Most all tasks carry some negative consequence of error. Here we are speaking of consequences which carry high cost penalty, loss of life, and the like (breaking an expensive piece of equipment, crashing an airplane, loss of a large customer). | A job task that carries criteria which, if not met, results in high consequences is a good candidate for aiding. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Harless (1986) | task changeability | high | The way in which the task is currently being performed is apt to change because of anticipated changes in the state-of-the-art, new policy, changes in tools or equipment, and so forth. In such cases (other variables being equal), it is often not worth... | A job task that uses a method of performance with high change probability in the future is a good candidate for aiding. |
| | aiding barriers | no | The task must be performed at a high rate; the performance environment precludes or makes use of job aid difficult; the frequency of the task makes investment in recall training worth it; the performer would not use the job aid because if a loss ... | A job task that does not involve factors which would tend to rule out guiding performance with job aid, is a good candidate for aiding. |
| Irvin et al. (1988) | skill manipulation | easy, moderately easy, moderately difficult, difficult | This factor refers to how difficult the adjustments, alignments, and measurements required to perform this task are. *Example of easy skill manipulation-adjusting volume on TV set.* *Example of difficult skill manipulation-cutting a diamond.* | |
| | number of steps | 1-4, 5-10, 11-20, 21+ | Number of steps required to perform task | |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Irvin et al. (1988) | adherence to procedures | low, moderately low, moderately high, high | This factor refers to whether a fixed sequence of steps is required when performing this task. *Example of low adherence to procedures-vacuuming a carpet. Example of high adherence to procedures-opening a combination lock.* | |
| | speed of response | inadequate, moderately inadequate, moderately adequate, adequate | This factor refers to the amount of time the technician has to respond or react when a task arises, i.e. is this an emergency procedure and/or does the technician have time to refer to a manual or printed instructions. *Example of inadequate time- helping a choking victim. Example of adequate time-writing a monthly report.* | |
| | rate of response | inadequate | This factor refers to the amount of time the technician has to refer to a manual while the technician is performing this task. *Example of inadequate time-administering CPR. Example of adequate time-troubleshooting a computer.* | |
| | crew size | one, two, three, four or more | This factor refers to how many people are required to safely perform this task. | |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Irvin et al. (1988) | accessibility | easy, moderately easy, moderately difficult, difficult | This factor refers to how difficult it is to access the components required to perform this task; for example, do a series of components need to be performed in order to get to the components? *Example of easy accessibility-replacing a light bulb. Example of difficult accessibility-repairing a heart valve.* | |
| | frequency | once every day or week,once every month, once every 2-6 months, once every 7+ months | This factor refers to how often or frequently this task is performed on the job. | |
| | practice | 1-3, 4-6, 7-9, 10+ | This factor refers to how many times this task must be practiced on-the-job in order to perform it to an acceptable level. | |
| | skill retention | 0-2 months, 3-5 months, 6-8 months, 9+ months | This factor refers to how long the skills required for this task can be retained or remembered without practicing them once proficiency is attained. | |
| | visual aids | small, moderately small, moderately large, large | This factor refers to how much this task would benefit from illustrations, tables, flow charts, and/or schematics. *Example of small benefit-using a hammer. Example of large benefit-assembling a machine gun.* | |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Irvin et al. (1988) | accuracy | low,<br>moderately low,<br>moderately high,<br>high | This factor refers to how important it is that this task be performed correctly each time and whether safety would be compromised if it is improperly performed and/or not performed at all. *Example of low accuracy task- washing a car.*<br>*Example of high accuracy task- diagnosing a disease.* | |
| | decision making | simple, moderately simple<br>moderately complex,<br>complex | This factor refers to the complexity of the decisions required to perform this task. For example, are the decisions simple i.e. binary, or are decisions based on evaluating numerous conditions? *Example of a simple decision- answering a true/false question. Example of a complex decision- preparing an attack for war.* | |
| Lineberry (1977) | error consequences | high | | Develop job aids when the consequences of error are high. |
| | amount of behavior | large | | Develop job aids when the amount of behavior is large and aids are not excluded. |
| | performance frequency | infrequent | | Develop job aids when the behavior is performed infrequently and the use of aids is not precluded. |
| | performance frequency | frequent | | If task is performed very frequently, or if the learning of the task helps performance of another task, then provide instruction. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Lineberry (1977) | performance methods | changeable | | Develop job aids when the performance methods are likely to change and aids are not precluded. |
| | time and budget | limited | | Develop job aids when limited time and/or budget is available and aids are not precluded. |
| | performance rate | severe | | If the performance task has a rate-of-performance criterion that would make using a job aid impossible, then provide instruction. |
| | aiding possible | constraints | | Provide instruction when the use of job aids is impractical or inappropriate. |
| | task newness | new/undefined | | If the performance task is so new or undefined that the detailed steps of mastery are unknown, but some general rules are known, then provide instruction with many different examples. |
| | performance consequences | high | | If high accuracy/completeness required because of high consequences and aids are not precluded then develop job aids. |
| | psychosocial effects | important | | If psychosocial factors are important and there is no way that they can be minimized then provide instruction. |
| | number of discriminations/decisions | large | | If performance task involves a large number of discriminations or decisions and aids are not precluded, then develop job aids. |
| | task learnability | difficult | | If the task is difficult to learn on the job then train. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
|---|---|---|---|---|
| Mockovak (1983) | communicability | difficult | | If the task is difficult to communicate in words then train. |
| | practice | a great deal | | If the task requires a great deal of practice then train. |
| | error tolerance | little | | If the task allows little tolerance for error then train. |
| | performance frequency | frequent | | If the task must be frequently performed then train. |
| | performance frequency | infrequent | | If the task is rarely performed then aid. |
| | performance rate | fast | | If the task does not allow time to refer to a manual then train. |
| | number of individuals | large | | If the task must be performed by a large number of individuals in the job area then train. |
| | behavior sequence | long and complex | | If the task has a long and complex behavior sequence then aid. |
| | task type | readings, tolerances, lookups | | If the task involves readings, tolerances, and lookups then aid. |
| | mental rehearsal | yes | | If the task can be mentally rehearsed prior to performance then train. |
| | illustratability | high | | If the task benefits greatly from the use of illustrations then aid. |
| Rossett and Downes (1991) | performance frequency | frequent | | If the performance is frequent then consider aiding. |
| | task complexity | multistep/multi-attribute | | If the task is a complex, multistep or multi-attribute situation then consider aiding. |
| | error consequence | high | | If the consequences of error are high then consider aiding. |

| Author(s) | Variable | Level(s) | Definition | Recommendations |
| --- | --- | --- | --- | --- |
| Rossett and Downes (1991) | amount of information | large | | If performance relies upon a large body of information then consider aiding. |
| | information changeability | frequent | | If performance relies upon knowledge, procedures or approaches that change frequently then consider aiding. |
| | mental reorientation | high | | If an employee must look at things in a new way or self-assess and correct performance with important or new standards in mind then consider aiding. |
| | time available | little | | If there is little time or few resources to devote to training then consider aiding. |
| | psychosocial effects | important | | If it damages credibility to use an aid then train. |
| | performance rate | high | | If speedy performance is a priority then train. |
| | task newness | high | | If novel and unpredictable situations are involved then train. |
| | task type | smooth/fluid | | If smooth and fluid performance is a top priority then train. |
| | motivation | questionable | | If there is some question about the motivation of a particular employee or the morale of a group of employees then aiding may not be used. |
| | aptitude | low | | If the employee lacks sufficient reading, listening or reference skills then train. |

## APPENDIX B

Standardization of the Job Aiding/Training Attributes.

- This appendix presents the culmination of an attribute standardization effort designed to eliminate redundancy and ambiguity amongst the attributes extracted from the literature review.

- Common names for the attributes have been provided along with the original variable name. For example, "technician aptitude" has been replaced with the more generic name "personnel aptitude."

- Where multiple authors provided similar but slightly different definitions of the same attribute, all definitions have been included.

| New Nomenclature | Original Variable | Definition | Authors Name |
|---|---|---|---|
| aiding barriers | aiding barriers | The task must be performed at a high rate; the performance environment precludes or makes use of job aid difficult; the frequency of the task makes investment in recall training worth it; the performer would not use the job aid because of loss of credit or other psychological or social reasons. | Harless (1986) |
| equipment complexity | equipment complexity | Equipment complexity is primarily a function of how many pieces or parts are required to make it operate reliably. Complexity may vary depending on the type of equipment (eg. electrical, mechanical, digital electronics). | Booher (1978) |
| equipment hazards | equipment hazards | Equipment hazards, which identify tasks that, if improperly performed, can cause minor hardware damage or major damage to abort the mission. | Goins et al. (1989) |
| performance rate (response) | rate of response | This factor refers to the amount of time the technician has to refer to a manual while the technician is performing this task. *Example-administering CPR requires a high rate of response. Troubleshooting a computer does not.* | Irvin et al. (1988) |
| performance rate (response) | speed of response | This factor refers to the amount of time the technician has to respond or react when a task arises. *Example- helping a choking victim requires a high speed of response where writing a monthly report does not.* | Irvin et al. (1988) |
| personnel aptitude | technician aptitude | **Low**- Functional literacy (5th grade) and spatial ability of minimum level for operator or maintenance activities; for example, at least 40 but not 45 on GCT,ARI, and MECH tests.<br>**Mid**- 9th grade reading level or above. Score between 45 and 60 on GCT, ARI, MECH tests.<br>**High**- Score 60 or better on GCT, ARI, MECH tests. | Booher (1978) |

| New Nomenclature | Original Variable | Definition | Authors Name |
|---|---|---|---|
| personnel experience | technician experience | **Low**- 0-6 months of actual on-job experience.<br>**Mid**- 6-12 months of actual on-job experience in specific equipments; 1-2 years of job experience on varied equipment types, but no theory.<br>**High**- More than 1 yr. on specific equipment; 2-4 yrs. of varied experience across equipment types, having had classroom theory, with special training in use of deductive aids. | Booher (1978) |
| personnel hazards | personnel hazards | Personnel hazards which identify tasks that, if improperly performed, can cause injury or death to the performer or others. | Goins et al. (1989) |
| practice | practice | This factor refers to how many times this task must be practiced on-the-job in order to perform it to an acceptable level. | Irvin et al. (1988) |
| psychosocial barrier | psychosocial barrier | ...hampers effective interactions with others involved in the job performance.<br>...damage to credibility... | Bullock (1982)<br><br>Rossett and Downes (1991) |
| resources | time and budget | Time and budget available | Lineberry (1977) |
| skill retention | skill retention | This factor refers to how long the skills required for this task can be retained or remembered without practicing them once proficiency is attained. | Irvin et al. (1988) |
| task complexity (access) | accessibility | This factor refers to how difficult it is to access the components required to perform this task; for example, do a series of components need to be performed in order to get to the components? *Example- replacing a lightbulb is highly accessible, but repairing a heart valve is not.* | Irvin et al. (1988) |

| New Nomenclature | Original Variable | Definition | Authors Name |
|---|---|---|---|
| task complexity | task complexity | Task complexity varies with maintenance philosophy, task frequency, and task difficulty (eg. requiring precision motor skills, coordination of interdependent tolerance, or alternative forms of accomplishing the action).<br>A task containing numerous steps (complex because of quantity) is more complex than a task of few steps. The task is qualitatively complex when fine discrimination of stimuli is involved, or recognition of stimuli belonging to the same class, or a series of binary discriminations such as inspecting or troubleshooting. | Booher (1978)<br>Harless (1986) |
| task complexity (change) | adherence to procedures | This factor refers to whether a fixed sequence of steps is required when performing this task. *Example-vacuuming a carpet is highly changeable, opening a combination lock is not.*<br>The way in which the task is being currently is apt to change because of anticipated changes in the state-of-the-art, new policy, changes in tools or equipment, and so forth. | Irvin et al. (1988)<br>Harless (1986) |
| task complexity (decisions) | decision making | This factor refers to the complexity of the decisions required to perform this task. For example, are the decisions simple i.e. binary, or are decisions based on evaluating numerous conditions? *Example- Answering a true/false question is simple, preparing an attack in war is complex.* | Irvin et al. (1988) |
| task complexity (novelty) | new skills or knowledge (task newness) | New skills or knowledge required to perform the task.<br>Task newness, which is the determination of whether or not the student has previous experience in learning how to do the task or in task performance on the job. | Goins et al. (1989) |
| task complexity (skill) | skill manipulation | This factor refers to how difficult the adjustments, alignments, and measurements required to perform this task are. *Example-adjusting volume on TV set is an easy task, cutting a diamond is a difficult task.* | Irvin et al. (1988) |
| task complexity (steps) | number of steps | Number of steps required to perform task | Irvin et al. (1988) |

| New Nomenclature | Original Variable | Definition | Authors Name |
|---|---|---|---|
| task criticality | task criticality | Task criticality, which is a measure of the importance of performing the task in meeting the goal. | Goins et al. (1989) |
| | | Most all tasks carry some negative consequence of error. Here we are speaking of consequences which carry high cost penalty, loss of life, and the like (breaking an expensive piece of equipment, crashing an airplane, loss of a large customer). | Harless (1986) |
| | | This factor refers to how important it is that this task be performed correctly each time and whether safety would be compromised if it is improperly performed and/or not performed at all. *Example- Low accuracy is required in washing a car, but high accuracy is required in diagnosing a disease.* | Irvin et al. (1988) |
| task frequency | performance frequency | This factor refers to how often or frequently this task is performed on the job. | Irvin et al. (1988) |
| | | A task performed once a year is certainly characterized as infrequent. A task performed every day is probably not low frequency. | Harless (1986) |
| | | Task frequency, which identifies performances that are frequent enough so that the student will not forget what to do between learning the task and performing that task on the job for the first time. | Goins et al. (1989) |
| task type | task type | **Troubleshooting-** Test equipment setup, operation, alignment-adjustment procedures, fault isolation, signal tracking, remove-replace failed component. **Non-troubleshooting-** operator tasks, preventive inspection, maintenance, servicing, simple repairs, disassembly, assembly, remove-install, calibration. | Booher (1978) |
| team size | crew size | This factor refers to how many people are required to safely perform this task. | Irvin et al. (1988) |

| New Nomenclature | Original Variable | Definition | Authors Name |
| --- | --- | --- | --- |
| visual aids | visual aids | This factor refers to how much this task would benefit from illustrations, tables, flow charts, and/or schematics.<br>*Example-Using visual aids would produce a small benefit in demonstrating the use of a hammer, but a high benefit would result in teaching the assembly of a machine gun.* | Irvin et al. (1988) |

## APPENDIX C

Example JATAT Analysis

## Introduction

• This appendix presents an example aiding/training decision analysis employing both the currently available approaches reviewed earlier in this report and the JATAT decision process and its supporting decision model.

• These independent analyses enable a comparative evaluation of the competing approaches, pin-pointing the strengths and weaknesses of each.

## Scenario

• A new electronic measuring device for troubleshooting engine system malfunctions has been recently developed and is expected to be operationally implemented in the near future.

• In conjunction with implementing the new device, it is deemed necessary to perform an analysis on the current training/aiding program (making modifications where necessary) to ensure a trouble-free transition into the operational setting.

• The following text summarizes the scenario in the context of the 454X0 Task Analysis document.

• TASK CHANGE: One task which is influenced by the new measuring device is "troubleshoot engine system malfunctions on flightline."

• ACTIVITIES CHANGE: None. The activities of this task are the same regardless of new measuring devices. (The activities are formulate possible causes of malfunction, remove/install suspect component, inspect, test/replace suspect component, functionally test system.)

• SKILLS CHANGE: Only one skill- "use measuring devices" is influenced by the new device.

• KNOWLEDGE CHANGE: Two types of knowledge are influenced by the new device- "interpret gauges and meters", and "locate parts/components/sections."

• Note that this summary corresponds to the task decomposition stage of the decision process diagram in Figure 3.

• The result of the decision flowchart is a need to evaluate the new knowledge and skills.

## Analysis Using Currently Available Models

| FACTOR | IMPLICATION |
|---|---|
| **Harless, Lineberry, and Rossett & Downes Model (See Figure 22.)** | |
| Task definition: clearly defined | Aiding > Training |
| Information quantity: low | Training > Aiding |
| Training resources: few | Aiding > Training |
| Performance frequency: infrequent | Aiding > Training |
| Task changeability: infrequent | Training > Aiding |
| Error consequence: high | Aiding > Training |

• The ">" indicates that one approach is recommended over the other.

"Barriers to Aiding" Model (See Figure 23.)

Time required: .5 hour
Time available: 1.5 hour
Performance rate: 3

Conclusion: Employ Aiding

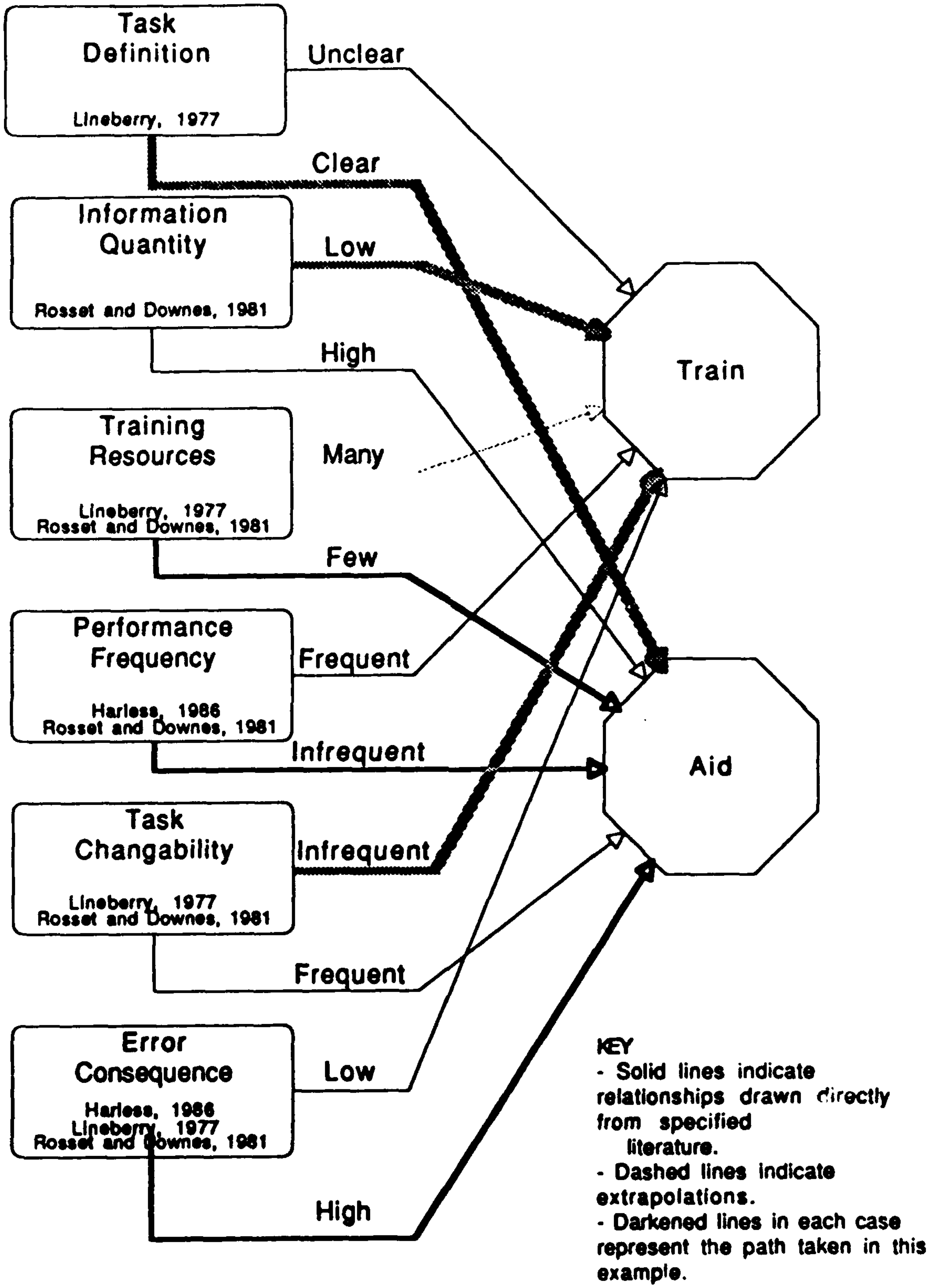
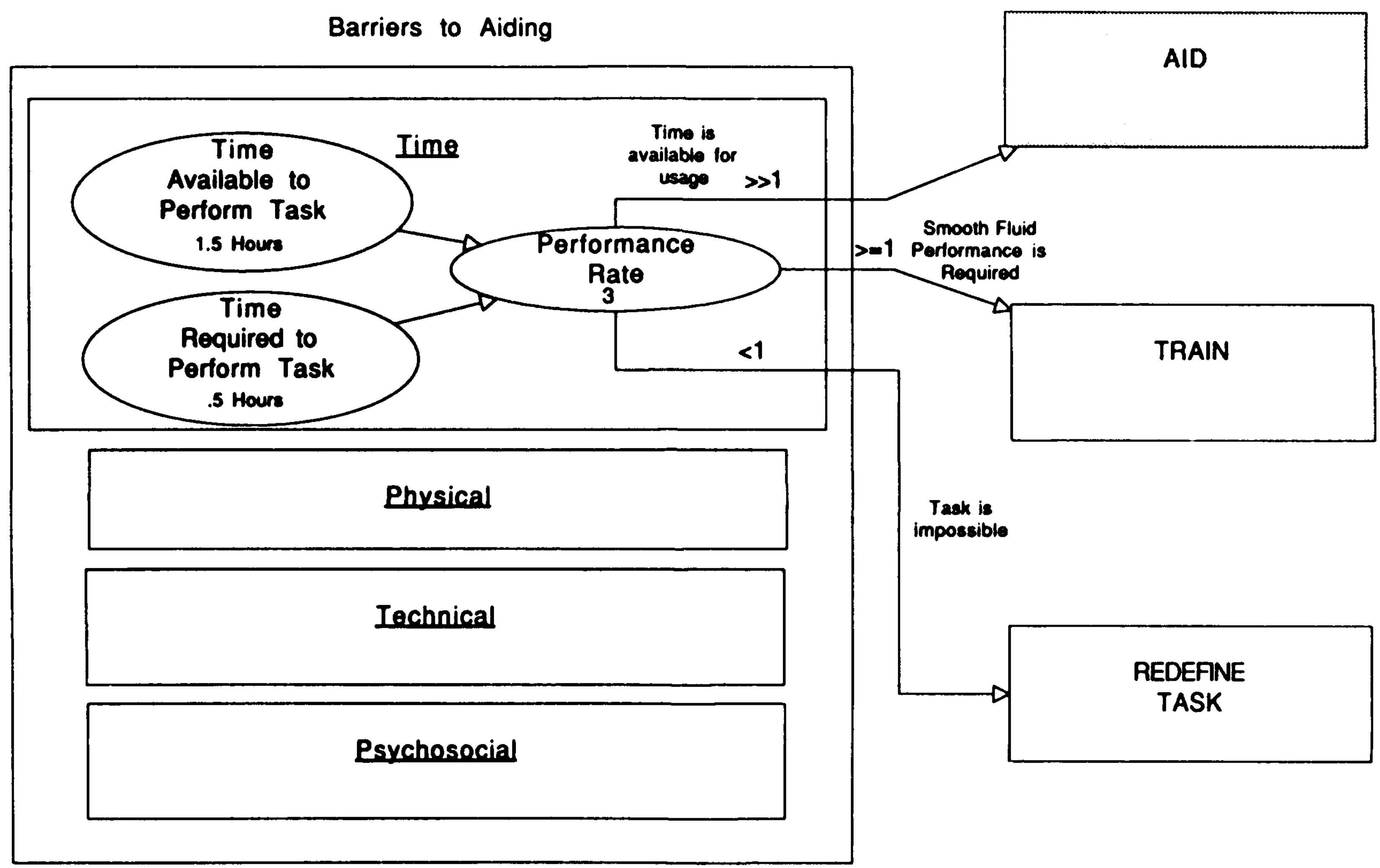



Figure 22. Example Attribute-Solution Relationships




- The shaded box indicates the recommended solution.

Figure 23. Example Barrier to Aiding

Goins Model (See Figure 24.)

Equipment hazards: no
Task criticality: high
Personal hazards: no
New skills required: no
Performance Frequency: < 3 months
New knowledge required: yes

Suggest: Training > Aiding

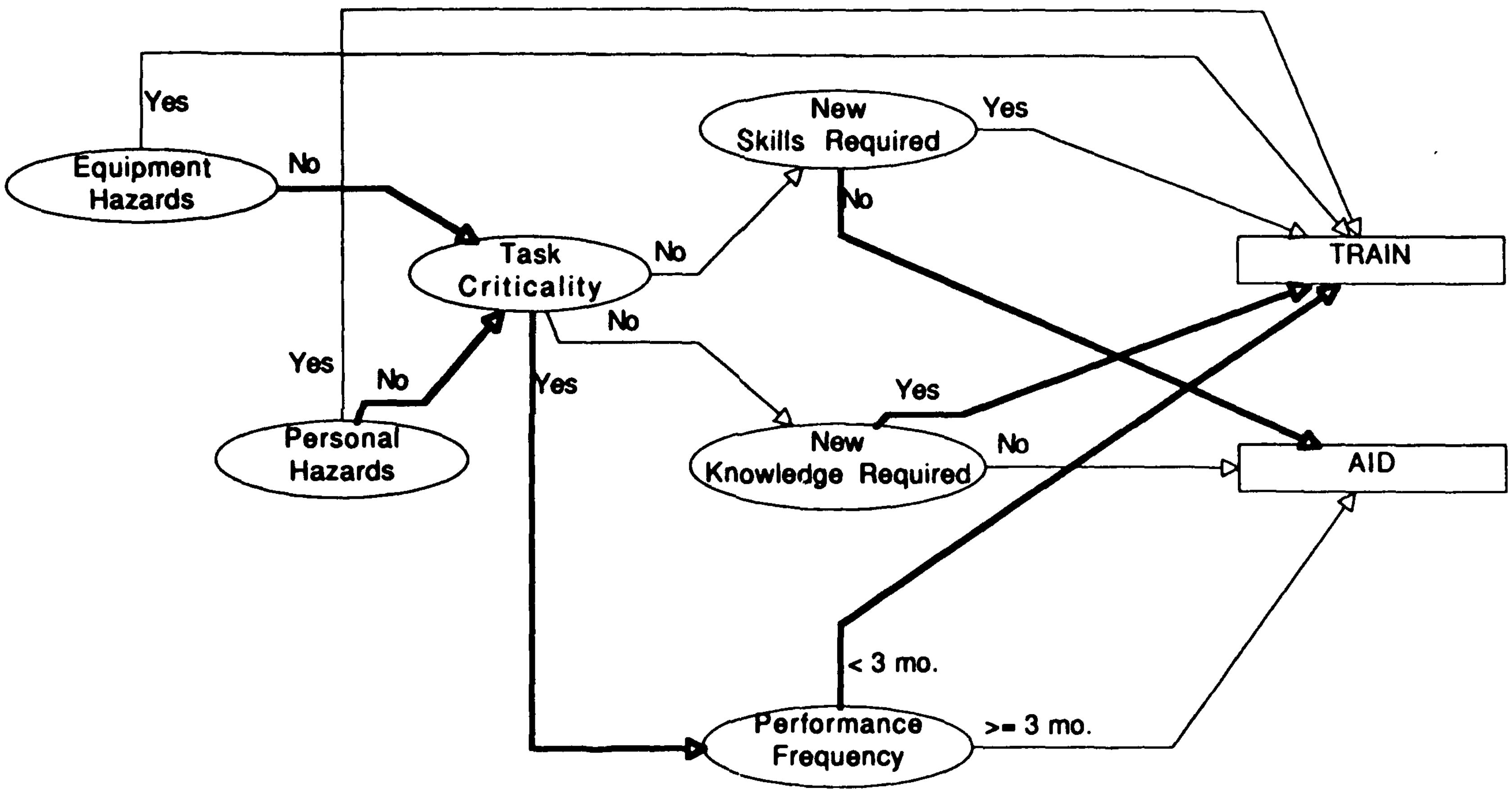
## Conclusions

• From the Harless, Lineberry, and Rossett & Downes Model: AID.
(Of the first six variables, four suggest aiding while two suggest training. It should be noted that the two variables which point to training are logical extrapolations and are not mentioned in the literature.)

• From the Barriers to Aiding Model: AID.
(There are no barriers to aiding with respect to time.)

• From the Goins Model: TRAIN.
(Although the task is critical, the frequency of performance is less than three months.)

• This analysis indicates that simple equal-weighted analysis schemes can sometimes end in contradictory results. Unfortunately, these methods do not provide the analyst with more specific information about the decision process and, hence, there are no means of resolving the conflict.




- The darkened lines indicate the path taken through the network in this example.

Figure 24. Example Inter-Attribute Relationships

• A simple knowledge-based approach, in contrast, would be able to isolate specific inflection points (single variables which contradict the conclusion) providing a much clearer rationale behind the recommendations of the analysis.

## Recommendations

• What follows is a hypothetical example of the results of a simple knowledge-based analysis.

• For any analysis, there will be certain critical attributes which have a particularly strong influence on the resultant conclusion. These critical attributes can either be negatively associated with the outcome (i.e., barriers to aiding or training) or positively associated with the outcome (i.e., critical juncture in a relationship network).

• Identification of these critical attributes is important to forming useful explanations of the recommendations.

• It seems that the critical attributes in this tradeoff (in this case, favoring aiding) are: training resources, performance frequency, error consequence, and task criticality.

• IF an aid can be inexpensively produced, and the performance frequency does not demand training, THEN AID.

• IF the training for the new measurement device is less expensive than the development of an aid, or if the information to be trained is not extensive, or the cognitive skills are not demanding, THEN TRAIN.

• It is apparent that these recommendations are not particularly insightful, however they do point out potential trade-offs which the JATAT user then could consider in more detail.

## JATAT Model Analysis

• Given that the applicable knowledge and skills for the analysis have been identified (see previous section), the analysis begins with Figure 4. at the point of evaluating these knowledge and skills.

• The physical requirement of the "use measuring devices" skill is essentially a manual dexterity manipulation. This can be easily accomplished by current personnel. Therefore, the behavior must be instructed.

• The knowledge component of this skill corresponds to the "interpret gauges and meters" knowledge previously identified and would be analyzed accordingly.

• It appears that there are no foreseen barriers to aiding for either of these knowledge types.

• The high task criticality and the new knowledge required imply that aiding of this task alone would be insufficient.

• There also appears to be no foreseen barriers to training. Therefore, some combination of training and aiding are appropriate for this task. (See Figure 25.)

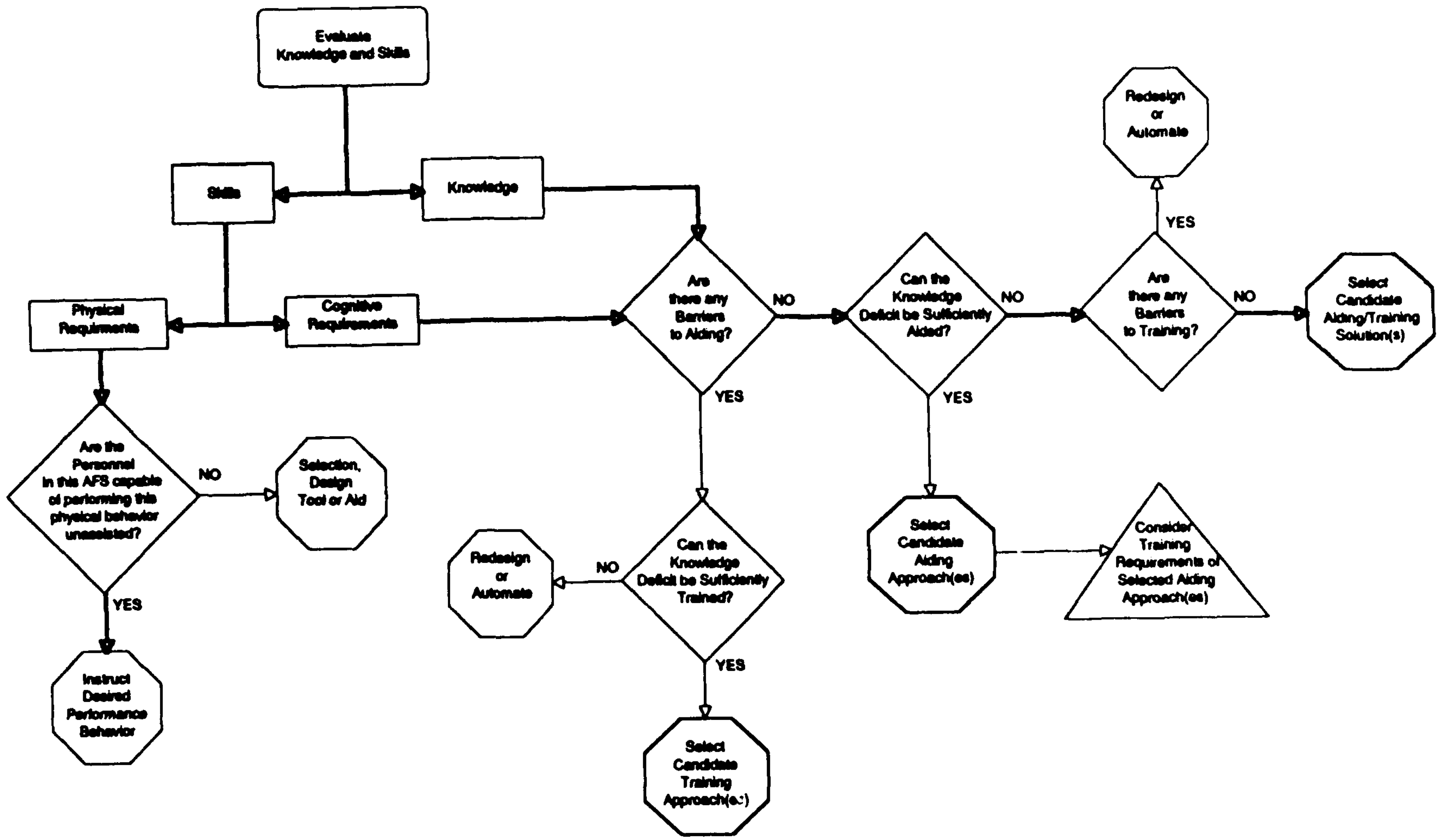



Figure 25. Example JATAT Path Analysis

# APPENDIX D

Regression Coefficients for Attribute-Solution Relationships

**Regression Coefficients for Display Information**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 118.192 | 125.455 | 102.013 | 84 | 110.732 | | 67.448 |
| Aptitude | -16.462 | | | | | | -11.32 |
| Experience | | 25.568 | | | | | |
| Number of Steps | | | | | | | 8.54 |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | -51.818 | | 3 | | | 15.366 |
| Performance Rate | | | | | | | |
| Criticality | | | | | | | |
| Hazards | | | | | | | |
| Information Amount | | | -8.636 | | | | |
| Number of Components | | | | | | | |
| Training Resources | | -48.068 | | -27 | | | |
| Aiding Technologies | | | | | -9.268 | | |

**Regression Coefficients for Monitor Performance**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 33 | 64.535 | 8.205 | | | 10 | 5.625 |
| Aptitude | | | 10.256 | | | | |
| Experience | | | | | | | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | -13 | | | | | | |
| Performance Rate | | | | | | 5 | |
| Criticality | | | | | | | |
| Hazards | | 11.744 | | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | | | |
| Training Resources | | | | | | 15 | |
| Aiding Technologies | | | | | | | 13.75 |

**Regression Coefficients for Assist Execution**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | 100 | | 89.959 | | | 90 |
| Aptitude | | | | | | | |
| Experience | | | | | | | -20 |
| Number of Steps | | | | -17.932 | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | | |
| Performance Rate | | | | | | | |
| Criticality | | | | | | | |
| Hazards | | | | 26.622 | | | |
| Information Amount | | | | | | | |
| Number of Components | | -60 | | -22.108 | | | |
| Training Resources | | | | | | | -10 |
| Aiding Technologies | | | | | | | |

**Regression Coefficients for Information Aid**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 11.815 | | 35.723 | 195 | 82.716 | 35.675 | 8.428 |
| Aptitude | | | | | | | |
| Experience | | | | | | -9.74 | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | 10.321 | |
| Motor Skills | | | | | | 11.555 | |
| Frequency | | | | | | | 15.96 |
| Performance Rate | | | | | | | |
| Criticality | 8.397 | | | | -20.56 | | |
| Hazards | | | -14.868 | | | | 8.885 |
| Information Amount | | | 12.601 | -5 | | | |
| Number of Components | | | | | | | |
| Training Resources | | | | -85 | | | |
| Aiding Technologies | | | | | | | |

**Regression Coefficients for Procedural Aid**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 115.026 | | 65.737 | | 79.375 | -10 | |
| Aptitude | | | -12.434 | | | | |
| Experience | -18.784 | | | | | 30 | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | | |
| Performance Rate | | | | | -11.563 | | |
| Criticality | | | | | | | |
| Hazards | | | 14.166 | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | | | |
| Training Resources | 11.005 | | | | 13.125 | | |
| Aiding Technologies | -18.46 | | | | | | |

**Regression Coefficients for Algorithmic Aid**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | | 59.231 | -90 | | | |
| Aptitude | | | | | | | |
| Experience | | | | | | | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | | |
| Performance Rate | | | -16.923 | | | | |
| Criticality | | | | | | | |
| Hazards | | | | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | | | |
| Training Resources | | | | 63.333 | | | |
| Aiding Technologies | | | | | | | |

**Regression Coefficients for Heuristic Aid**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | | 40 | | | 11.376 | 97.5 |
| Aptitude | | | 5 | | | | |
| Experience | | | | | | | |
| Number of Steps | | | | | | | 20 |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | 13.492 | |
| Performance Rate | | | -5 | | | | |
| Criticality | | | | | | 10.847 | 5 |
| Hazards | | | | | | | |
| Information Amount | | | 5 | | | | -17.5 |
| Number of Components | | | | | | | |
| Training Resources | | | | | | | |
| Aiding Technologies | | | | | | | -7.5 |

**Regression Coefficients for Assistive Aid**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | | | | | | -5 |
| Aptitude | | | | | | | |
| Experience | | | | | | | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | | |
| Performance Rate | | | | | | | |
| Criticality | | | | | | | |
| Hazards | | | | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | | | |
| Training Resources | | | | | | | 15 |
| Aiding Technologies | | | | | | | |

**Regression Coefficients for Information Presentation**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 23.644 | -28.328 | 59.874 | | 65.173 | 44.5 | 56.49 |
| Aptitude | | | | | | | |
| Experience | | 34.854 | | | | | |
| Number of Steps | 7.173 | | | | | | |
| Mental Skills | | 11.153 | | | -23.318 | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | 20.094 | | |
| Performance Rate | | | | | | | |
| Criticality | | | | | | | |
| Hazards | | | | | | | |
| Information Amount | | -23.458 | | | | -13.7 | -17.55 |
| Number of Components | | | -8.808 | | | | |
| Training Resources | | | -10.956 | | -10.928 | | |
| Aiding Technologies | | | | | | | |

**Regression Coefficients for Modeling**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 21.01 | 65.464 | 42.212 | 6.5 | | | 37.99 |
| Aptitude | | | | 6.5 | | | |
| Experience | | | | | | | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | 6.296 | | | | | | 11.778 |
| Performance Rate | | | | 3.5 | | | -201 |
| Criticality | | | | | | | |
| Hazards | | | | -1 | | | |
| Information Amount | | -14.691 | -5.192 | | | | |
| Number of Components | | | | | | | |
| Training Resources | | | | | | | |
| Aiding Technologies | | | | | | | |

## Regression Coefficients for Coaching

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 62.092 | | 49.93 | 18.214 | 1.938 | 11.277 | 57.226 |
| Aptitude | | | | 7.836 | | | -12.705 |
| Experience | | | | | | | |
| Number of Steps | -6.252 | | | | 13.097 | | |
| Mental Skills | | | | | 12.516 | | |
| Motor Skills | | | | 7.684 | | | 21.646 |
| Frequency | | | | 12.091 | | | |
| Performance Rate | -7.867 | | | | | | |
| Criticality | | | | | | 11.702 | |
| Hazards | | | | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | -4.641 | | -9.434 |
| Training Resources | | | 8.71 | | | | |
| Aiding Technologies | | | -11.266 | | | | |

## Regression Coefficients for Exploration

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 50 | 70.828 | 40 | 33 | 37.885 | 26.651 | 14.46 |
| Aptitude | | -10.268 | | | | | |
| Experience | | | | | | | 7.079 |
| Number of Steps | | | | | | | |
| Mental Skills | | -11.723 | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | -9.449 | 10 | | | | -22.289 |
| Performance Rate | | 20.924 | | | 12.401 | 9.36 | 33.636 |
| Criticality | | | | | | | -9.308 |
| Hazards | | | | 33.5 | -6.627 | | |
| Information Amount | | | -10 | | | 7.326 | |
| Number of Components | | | | | | -9.523 | |
| Training Resources | | -10.534 | | | | | |
| Aiding Technologies | -10 | | | | -14.301 | | 4.18 |

**Regression Coefficients for Classroom**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | 0.764 | 52.237 | 52.534 | 75.492 | 177.375 | 90.962 |
| Aptitude | | | 6.155 | | | | |
| Experience | | 2.156 | | | | -20.125 | |
| Number of Steps | | | | | | | |
| Mental Skills | | 6.917 | | | | | -22.788 |
| Motor Skills | | -5.402 | -6.521 | | -12.505 | | |
| Frequency | | | | | | | |
| Performance Rate | | | | | -12.035 | 30 | |
| Criticality | | | -5.791 | -10.502 | | -58.25 | |
| Hazards | | | | | | -15 | |
| Information Amount | | | | | | | -12.019 |
| Number of Components | | 4.461 | | | | 6.875 | |
| Training Resources | | | -10.467 | | | | |
| Aiding Technologies | | | | 6.895 | | | |

**Regression Coefficients for Independent Study**

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | -16 | | | | | 10 |
| Aptitude | | 10 | | | | | |
| Experience | | 10.667 | | | | | |
| Number of Steps | | | | | | | |
| Mental Skills | | | | | | | |
| Motor Skills | | | | | | | |
| Frequency | | | | | | | |
| Performance Rate | | | | | | | |
| Criticality | | | | | | | |
| Hazards | | | | | | | |
| Information Amount | | | | | | | |
| Number of Components | | | | | | | 23.333 |
| Training Resources | | | | | | | |
| Aiding Technologies | | | | | | | |

## Regression Coefficients for Simulators

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | -5.69 | 4.048 | 14.649 | -9.855 | 409.866 | 51.111 | |
| Aptitude | | | | | | | |
| Experience | | | 12.312 | | | | |
| Number of Steps | | | 1.889 | | | | |
| Mental Skills | 11.897 | | -7.481 | 16.614 | | 11.855 | |
| Motor Skills | | | | | 10 | | |
| Frequency | 12.586 | | -5.169 | 6.398 | | | |
| Performance Rate | | | -1.244 | | | | |
| Criticality | | 10.714 | | | | | |
| Hazards | | | | -6.457 | | | 15 |
| Information Amount | | | 5.257 | | | | |
| Number of Components | | | -1.065 | 10.387 | | | |
| Training Resources | | | | | | 16.344 | |
| Aiding Technologies | | | | | | | |

## Regression Coefficients for On-the-Job Training

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | | 143.997 | 87.5 | 30.106 | 25.569 | 60.415 | 83.008 |
| Aptitude | | -13.859 | | | | -22.059 | 0.668 |
| Experience | | | | | | -21.14 | 5.746 |
| Number of Steps | | | | | | 18.414 | |
| Mental Skills | | -10.842 | -7.5 | | | | -26.522 |
| Motor Skills | | | | | | | |
| Frequency | | -13.663 | | | 14.579 | | -19.754 |
| Performance Rate | | 8.871 | | | | | |
| Criticality | | -9.532 | | | | | 12.119 |
| Hazards | | -8.678 | | | | -11.554 | 21.39 |
| Information Amount | | | -7.5 | | | | |
| Number of Components | | | | | | 9.699 | -3.522 |
| Training Resources | | | | 16.277 | | 11.373 | |
| Aiding Technologies | | | | | | 24.395 | |

## APPENDIX E

Regression Coefficients for Expert
Aiding/Training Barrier, Sufficiency, and Combination Models

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 0.939 | 0.280 | -0.189 | 1.753 | 0.255 | 1.526 | 1.559 |
| Aptitude | -0.211 | -0.427 | -0.228 | -0.189 | -0.337 | -0.265 | -0.048 |
| Experience | -0.257 | 0.035 | 0.065 | 0.016 | -0.034 | 0.028 | 0.058 |
| Number of Steps | 0.123 | -0.243 | -0.149 | 0.002 | -0.142 | -0.418 | -0.296 |
| Mental Skills | 0.026 | 0.093 | 0.134 | -0.150 | 0.177 | -0.052 | -0.274 |
| Motor Skills | -0.072 | -0.147 | 0.126 | 0.110 | -0.026 | -0.120 | 0.245 |
| Frequency | 0.038 | 0.066 | -0.018 | -0.020 | -0.127 | -0.331 | -0.246 |
| Performance Rate | 0.072 | -0.104 | -0.177 | -0.015 | 0.061 | -0.116 | -0.004 |
| Criticality | -0.171 | 0.062 | 0.054 | -0.063 | -0.141 | -0.132 | -0.100 |
| Hazards | 0.171 | 0.096 | 0.121 | 0.125 | 0.111 | 0.237 | 0.143 |
| Information Amount | 0.029 | 0.089 | 0.066 | 0.005 | -0.198 | 0.012 | -0.138 |
| Number of Components | 0.187 | 0.075 | -0.123 | -0.206 | -0.048 | -0.024 | -0.102 |
| Training Resources | 0.144 | 0.304 | 0.114 | -0.014 | 0.070 | 0.301 | 0.091 |
| Aiding Technologies | -0.091 | 0.173 | 0.207 | -0.077 | 0.142 | 0.196 | -0.036 |

Regression Coefficients for Analysis of Aiding Barriers

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 0.000 | 0.332 | 0.000 | 0.361 | 0.000 | 0.233 | 0.000 |
| Aptitude | 0.000 | 0.016 | 0.000 | 0.007 | 0.000 | 0.143 | 0.000 |
| Experience | 0.000 | -0.014 | 0.000 | 0.074 | 0.000 | -0.047 | 0.000 |
| Number of Steps | 0.000 | -0.120 | 0.000 | -0.040 | 0.000 | -0.124 | 0.000 |
| Mental Skills | 0.000 | -0.058 | 0.000 | -0.108 | 0.000 | -0.047 | 0.000 |
| Motor Skills | 0.000 | -0.101 | 0.000 | -0.075 | 0.000 | 0.118 | 0.000 |
| Frequency | 0.000 | -0.048 | 0.000 | -0.023 | 0.000 | 0.066 | 0.000 |
| Performance Rate | 0.000 | -0.013 | 0.000 | 0.057 | 0.000 | 0.158 | 0.000 |
| Criticality | 0.000 | 0.015 | 0.000 | 0.013 | 0.000 | -0.233 | 0.000 |
| Hazards | 0.000 | 0.064 | 0.000 | -0.012 | 0.000 | 0.052 | 0.000 |
| Information Amount | 0.000 | 0.088 | 0.000 | -0.044 | 0.000 | 0.100 | 0.000 |
| Number of Components | 0.000 | -0.025 | 0.000 | 0.041 | 0.000 | -0.152 | 0.000 |
| Training Resources | 0.000 | -0.038 | 0.000 | -0.046 | 0.000 | -0.035 | 0.000 |
| Aiding Technologies | 0.000 | 0.030 | 0.000 | -0.079 | 0.000 | -0.052 | 0.000 |

Regression Coefficients for Analysis of Training Barriers

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | -0.700 | -0.281 | 0.431 | -0.086 | 0.967 | 0.520 | -0.185 |
| Aptitude | -0.105 | 0.022 | 0.039 | 0.147 | 0.153 | 0.254 | 0.270 |
| Experience | 0.066 | -0.021 | -0.134 | -0.101 | -0.051 | -0.083 | -0.323 |
| Number of Steps | 0.058 | 0.179 | 0.262 | -0.052 | 0.011 | 0.031 | 0.497 |
| Mental Skills | 0.159 | -0.177 | -0.149 | -0.043 | -0.263 | -0.006 | -0.238 |
| Motor Skills | -0.167 | -0.053 | 0.264 | 0.067 | 0.099 | 0.155 | -0.112 |
| Frequency | 0.040 | 0.118 | 0.081 | 0.082 | 0.135 | -0.012 | 0.076 |
| Performance Rate | -0.110 | -0.027 | 0.223 | 0.094 | -0.150 | 0.081 | 0.344 |
| Criticality | 0.120 | 0.267 | 0.063 | -0.098 | 0.065 | -0.175 | 0.269 |
| Hazards | 0.008 | -0.001 | -0.179 | 0.071 | -0.077 | -0.106 | -0.071 |
| Information Amount | -0.164 | -0.117 | -0.045 | 0.101 | -0.109 | -0.051 | 0.153 |
| Number of Components | 0.252 | 0.109 | -0.152 | -0.120 | -0.009 | -0.161 | -0.138 |
| Training Resources | 0.014 | -0.102 | 0.253 | 0.009 | -0.146 | -0.019 | -0.271 |
| Aiding Technologies | 0.324 | 0.089 | -0.209 | -0.066 | -0.063 | -0.121 | -0.256 |

Regression Coefficients for Analysis of Aiding Sufficiency

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 0.799 | 1.217 | 1.168 | 1.818 | -0.408 | 2.622 | 1.581 |
| Aptitude | -0.147 | -0.042 | -0.036 | -0.188 | -0.065 | -0.293 | -0.284 |
| Experience | 0.044 | -0.068 | -0.011 | 0.029 | -0.068 | 0.295 | 0.150 |
| Number of Steps | -0.011 | -0.448 | 0.060 | -0.006 | 0.220 | -0.480 | -0.356 |
| Mental Skills | 0.119 | 0.179 | 0.060 | -0.170 | -0.027 | -0.497 | 0.166 |
| Motor Skills | 0.038 | -0.047 | -0.267 | 0.096 | -0.284 | -0.658 | 0.097 |
| Frequency | 0.193 | -0.178 | 0.084 | -0.024 | 0.086 | -0.093 | -0.046 |
| Performance Rate | -0.328 | 0.268 | -0.181 | -0.005 | 0.102 | 0.244 | -0.245 |
| Criticality | 0.100 | -0.333 | -0.126 | -0.061 | 0.194 | 0.166 | -0.262 |
| Hazards | 0.247 | 0.222 | 0.054 | 0.123 | 0.236 | 0.313 | 0.206 |
| Information Amount | -0.102 | 0.269 | -0.178 | -0.003 | 0.104 | -0.152 | -0.211 |
| Number of Components | -0.111 | -0.180 | 0.249 | -0.199 | 0.028 | 0.339 | -0.011 |
| Training Resources | -0.015 | 0.040 | 0.114 | -0.023 | 0.104 | -0.188 | 0.178 |
| Aiding Technologies | -0.066 | -0.043 | -0.083 | -0.091 | -0.075 | -0.212 | 0.214 |

Regression Coefficients for Analysis of Training Sufficiency

| Attributes | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 |
|---|---|---|---|---|---|---|---|
| Constant | 0.149 | 0.064 | -0.716 | -0.732 | 0.441 | 0.354 | -0.396 |
| Aptitude | 0.291 | 0.019 | 0.062 | 0.040 | -0.088 | 0.093 | 0.014 |
| Experience | 0.070 | 0.089 | 0.182 | 0.072 | 0.119 | 0.237 | 0.173 |
| Number of Steps | -0.07 | 0.269 | 0.007 | 0.057 | -0.231 | 0.122 | -0.141 |
| Mental Skills | -0.164 | -0.002 | 0.074 | 0.213 | 0.290 | -0.198 | 0.072 |
| Motor Skills | 0.147 | 0.100 | -0.077 | -0.163 | 0.185 | 0.054 | 0.015 |
| Frequency | -0.214 | 0.060 | -0.176 | -0.057 | -0.221 | -0.048 | -0.030 |
| Performance Rate | 0.264 | -0.241 | 0.044 | -0.089 | 0.048 | -0.024 | -0.099 |
| Criticality | -0.068 | 0.067 | 0.090 | 0.159 | -0.259 | 0.078 | -0.008 |
| Hazards | -0.161 | -0.221 | -0.129 | -0.194 | -0.159 | -0.328 | -0.136 |
| Information Amount | 0.213 | -0.152 | -0.026 | -0.098 | 0.005 | -0.018 | 0.058 |
| Number of Components | -0.263 | 0.071 | 0.165 | 0.319 | -0.019 | 0.098 | 0.148 |
| Training Resources | -0.014 | 0.061 | 0.062 | 0.013 | 0.042 | -0.084 | 0.093 |
| Aiding Technologies | -0.136 | -0.046 | 0.135 | 0.156 | 0.138 | -0.138 | 0.042 |

Regression Coefficients for Analysis of Aiding/Training Combinations

# APPENDIX F

STUDY MATERIALS:
Task Scenarios/Profiles, Attribute Definitions, and Decision Questionnaire

TASK- REMOVE/ INSTALL SAFETY DEVICES ON ENGINE COMPONENT

SCENARIO

**Change which Precipitated the Analysis:**

In order to correct a history of mishaps due to RX32 engine component failures, a new safety device has been developed for the future tactical fighter which has proven to be highly effective. A decision has subsequently been made to retrofit this new safety device onto all existing aircraft.

**Personnel:**

The aircraft mechanics responsible for performing this retrofit are all 2nd term enlistees (i.e., they have all completed a three year enlistment and have re-enlisted for an additional three more years.) Their general aptitude scores are in the 40-80th percentile of the ASVAB. This is within a standard deviation of the mean.

**Task:**

Installing the new safety device is an elaborate procedure involving several hours of time and dozens of steps. A moderate amount of both mental and motor skills are required. While the number of mishaps resulting from a failure of this component is relatively low, the impact that such a failure has is relatively high. It is important that the safety device be installed but the total number of accidents which could be avoided is rather small. While the device itself is rather simple, with only 7 components, there is also a large amount of information to consider to ensure that it operates properly. The largest demand on the aircraft mechanic is integrating the device into the existing system. Until the entire inventory has been rotated through the maintenance facility the mechanics will be scheduled to install a new safety device approximately once every week.

**Environment:**

The installation of the safety device is performed in an aircraft maintenance depot.

**Currently Available Training Resources and Aiding Technologies:**

The safety devices are installed exclusively by aircraft maintenance mechanics at the maintenance depot. The current scheduling load appears to preclude extensive formal training to perform this installation and the novelty of the task has resulted in an inherent lack of experts to assist in OJT. The design contractor has supplied a series of installation technical manuals for support.

## Task Profile- Remove/Install Safety Devices on Engine Component

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low (0–40) | **mid** (40–80) | high (80–100) | | |
| Personnel Experience: Years | low (0–1) | mid (1–3) | **high** (3–3+) | | |
| Task Steps: Number | 1-3 | 4-9 | 10-14 | **15+** | |
| Mental Skills Required: | not applicable | low | **mid** | high | |
| Motor Skills Required: | not applicable | low | **mid** | high | |
| Task Frequency: | daily | **weekly** | monthly | yearly | |
| Task Performance Rate: | not applicable | **low** | mid | high | |
| Task Criticality: | not applicable | low | **mid** | high | |
| Task Hazards: | none | low | **mid** | high | |
| Information Amount: | unknown | low | mid | **high** | |
| Equip. Components: Number | not applicable | 1-3 | **4-9** | 10-14 | 15+ |
| Training Resources: | none | **low** | mid | high | |
| Aiding Technology: | none | **low** | mid | high | |

## TASK- TEST GEAR-BOX CARBON SEALS

## SCENARIO

**Change which Precipitated the Analysis:**

Trend analysis of Air Force-wide maintenance reports indicate an unexpectedly high failure rate of a new type of gear-box carbon seals. Since this seal design is used on several types of operational aircraft, a decision has been made to employ a new, more stringent test of all gear-box seals on the affected aircraft.

**Personnel:**

The aircraft mechanics typically expected to test these seals have nine months of technical school and three months of on-the-job experience. Their general aptitude scores are in the 80-90th percentile of the ASVAB.

**Task:**

Testing gear-box carbon seals is a laborious procedure involving only a handful of steps. The test itself results in a simple satisfactory/ unsatisfactory conclusion and requires very little information for the mechanic to consider. The main difficulty in testing is physically accessing the seals. Mechanics use a simple vacuum-testing device with only five components. It is important that the gear-box seals perform nominally since the gear-box is on the critical path for aircraft operation.The testing procedure will be performed at all air bases on a rotating three month basis.

**Environment:**

Carbon seal testing is performed in the hangar.

**Currently Available Training Resources and Aiding Technologies:**

Flightline maintenance NCO's have been briefed on the procedures associated with the new test and are responsible for training the more junior personnel to perform the test within the current OJT curriculum.

## Task Profile- Test Gear-Box Carbon Seals

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: | low | mid | **high** | | |
| ASVAB Gen Score | 0 | 40 | 80 | 100 | |
| Personnel Experience: | low | **mid** | high | | |
| Years | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | **4-9** | 10-14 | 15+ | |
| Mental Skills Required: | not applicable | **low** | mid | high | |
| Motor Skills Required: | not applicable | low | mid | **high** | |
| Task Frequency: | daily | weekly | **monthly** | yearly | |
| Task Performance Rate: | not applicable | low | **mid** | high | |
| Task Criticality: | not applicable | low | mid | **high** | |
| Task Hazards: | none | low | **mid** | high | |
| Information Amount: | unknown | **low** | mid | high | |
| Equip. Components: Number | not applicable | 1-3 | **4-9** | 10-14 | 15+ |
| Training Resources: | none | **low** | mid | high | |
| Aiding Technology: | none | **low** | mid | high | |

TASK - ADJUST DAILY MAINTENANCE PLANS
TO MEET OPERATIONAL COMMITMENTS

SCENARIO

**Change which Precipitated the Analysis:**

The increased rate of operational sorties flown in the recent Gulf Crisis has placed great demands on maintenance activity schedulers to handle large numbers of unexpected, high priority aircraft repairs while constrained by both time and a limited number of experience maintenance technicians. In effect, sortie rate generation is directly dependent upon the schedulers' abilities to resolve these problems.

**Personnel:**

These maintenance schedulers are Air Force Reservists whose experience with daily maintenance planning has been limited to monthly weekend and annual week-long service commitments. Their general aptitude scores are in the 75-95th percentile of the ASVAB. This is a full standard deviation above the mean.

**Task:**

Adjusting daily maintenance plans to meet operational commitments involves prioritizing and scheduling maintenance, and predicting what resources will be needed. It is critical that the most important maintenance tasks are accomplished by the most experienced personnel. Unfortunately, while such a task is typically dependent on thorough analyses of available information, the reactive nature of the combat environment avails itself to very little predictive data.

**Environment:**

Adjusting daily maintenance plans is performed in an office environment.

**Currently Available Training Resources and Aiding Technologies:**

A substantial portion of the schedulers' active duty assignments are targeted at developing more proficient scheduling skills. Current scheduling procedures are performed primarily by hand.

## Task Profile-
## Adjust Daily Maintenance Plans to Meet Operational Committments

| | | | | |
|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low | mid | high | |
| | 0 | 40 | 80 | 100 |
| Personnel Experience: Years | low | mid | high | |
| | 0 | 1 | 3 | 3+ |
| Task Steps: Number | 1-3 | 4-9 | 10-14 | 15+ |
| Mental Skills Required: | not applicable | low | mid | high |
| Motor Skills Required: | not applicable | low | mid | high |
| Task Frequency: | daily | weekly | monthly | yearly |
| Task Performance Rate: | not applicable | low | mid | high |
| Task Criticality: | not applicable | low | mid | high |
| Task Hazards: | none | low | mid | high |
| Information Amount: | unknown | low | mid | high |
| Equip. Components: Number | not applicable | 1-3 | 4-9 | 10-14 / 15+ |
| Training Resources: | none | low | mid | high |
| Aiding Technology: | none | low | mid | high |

TASK- ISOLATE MALFUNCTION WITH ENGINE SYSTEM

SCENARIO

**Change which Precipitated the Analysis:**

A new electronic testing device has been developed to assist aircraft mechanics in isolating malfunctions with the internal fuel flow control system of the F-100 jet engine.

**Personnel:**

The aircraft mechanics currently performing this task are second year enlistees (i.e., they have completed their first three year enlistment and are currently serving a second three year enlistment). Their general aptitude scores are in the 70-90th percentile of the ASVAB, which is approximately one standard deviation above the mean.

**Task:**

Isolating fuel flow controller malfunctions has five subtasks -- formulate possible causes of the malfunction, remove suspect component, inspect/test suspect component, replace component, and functionally test the system. The most difficult component of this task is formulating possible causes of the malfunction which correspond to the manifest symptoms. Once the mechanic has postulated a cause, the motors skills necessary for removing/replacing equipment components are at a much simpler level. The mechanic typically refers to technical specifications and repair manuals during task performance. These documents are voluminous. The new testing device provides more information to the mechanic than before, but it is fairly complicated to operate with dozens of components. Mechanics perform this task every few days and it may require several hours to isolate a particular malfunction. The task of isolating malfunctions is critical to the performance of the aircraft and safety of the crew.

**Environment:**

The controlled environment of the aircraft hangar (i.e., systems shut-down, fuel drained, controlled climate, etc.) presents few, if any, hazards to the mechanic.

**Currently Available Training Resources and Aiding Technologies:**

Currently, there are two major training resources, several months at a technical school and on-the-job experience. The repair manuals serve as the only available information aids.

Task Profile- Isolate Malfunction w/ Engine System

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low | mid | **high** | | |
| | 0 | 40 | 80 | 100 | |
| Personnel Experience: Years | low | mid | **high** | | |
| | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | **4-9** | 10-14 | 15+ | |
| Mental Skills Required: | not applicable | low | mid | **high** | |
| Motor Skills Required: | not applicable | low | **mid** | high | |
| Task Frequency: | daily | weekly | **monthly** | yearly | |
| Task Performance Rate: | not applicable | low | **mid** | high | |
| Task Criticality: | not applicable | low | mid | **high** | |
| Task Hazards: | none | **low** | mid | high | |
| Information Amount: | unknown | low | mid | **high** | |
| Equip. Components: Number | not applicable | 1-3 | 4-9 | 10-14 | **15+** |
| Training Resources: | none | low | **mid** | high | |
| Aiding Technology: | none | **low** | mid | high | |

TASK - EMPLOY LIFE-SAVING TECHNIQUES

SCENARIO

**The change which precipitated the analysis:**

The recent Gulf Crisis has required security police with less experience to handle tasks which normally were reserved for more experienced personnel.

**Personnel:**

The security police have three months of police training and a year of on-the-job experience. Their general aptitude scores are in the 75-95th percentile of the ASVAB (Armed Services Vocational Aptitude Battery). This is a full standard deviation above the mean.

**Task:**

Employing life-saving techniques requires a fair amount of mental skill. The decisions to be made are not especially difficult but the stress of the situation requires an amount of mental discipline. There are only a handful of steps necessary for rescue breathing, CPR, severe bleeding, poisoning, etc. The motor skills necessary to save a life are not demanding and the opportunity to use the skills are infrequent, perhaps only once in a year. The rate of performance is high of course, and the criticality of the task is very high. The hazards in performing the task are low. The amount of information to process is moderate.

**Environment:**

Employing life-saving techniques is primarily performed at the scene of incidents.

**Current methods of support:**

The following resources are available for supporting this task. Security police are extensively trained in advanced first aid and life-saving procedures. There are good life-saving manuals as well.

## Profile of 811XX Task- Employ Life-Saving Techniques

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low | mid | **high** | | |
| | 0 | 40 | 80 | 100 | |
| Personnel Experience: Years | low | **mid** | high | | |
| | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | **4-9** | 10-14 | 15+ | |
| Mental Skills Required: | not applicable | low | **mid** | high | |
| Motor Skills Required: | not applicable | **low** | mid | high | |
| Task Frequency: | daily | weekly | monthly | **yearly** | |
| Task Performance Rate: | not applicable | low | mid | **high** | |
| Task Criticality: | not applicable | low | mid | **high** | |
| Task Hazards: | none | **low** | mid | high | |
| Information Amount: | unknown | low | **mid** | high | |
| Equip. Components: Number | **not applicable** | 1-3 | 4-9 | 10-14 | 15+ |
| Training Resources: | none | low | mid | **high** | |
| Aiding Technology: | none | low | mid | **high** | |

TASK - CONDUCT ANTI-ROBBERY TRAINING

SCENARIO

**The change which precipitated the analysis:**

A recent surge in robberies in base housing has caused the base commander to provide anti-robber training for all interested personnel. The base security police have been assigned the task of conducting the training.

**Personnel:**

Senior security personnel have been selected to provide the training. Most of them have ten years or more experience. Their general aptitude scores are in the 40-80th percentile of the ASVAB (Armed Services Vocational Aptitude Battery). This is within a standard deviation of the mean.

**Task:**

Conducting anti-robbery training requires a moderate amount of mental skill but no specific motor skills. The training courses are to be offered once weekly for a month. The actual task of training requires responsiveness to questions and the ability to process a moderate amount of information.

**Environment:**

Anti-robbery training is conducted in a classroom environment.

**Current methods of support:**

The following resources are available for supporting this task. There is little formal training for personnel conducting anti-robber training but there are numerous visual aids, including a training film about how to protect your house from robbers.

## Profile of 811XX Task- Conduct Anti-Robbery Training

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low | **mid** | high | | |
| | 0 | 40 | 80 | 100 | |
| Personnel Experience: Years | low | mid | **high** | | |
| | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | **4-9** | 10-14 | 15+ | |
| Mental Skills Required: | not applicable | low | **mid** | high | |
| Motor Skills Required: | **not applicable** | low | mid | high | |
| Task Frequency: | daily | **weekly** | monthly | yearly | |
| Task Performance Rate: | not applicable | low | **mid** | high | |
| Task Criticality: | not applicable | **low** | mid | high | |
| Task Hazards: | **none** | low | mid | high | |
| Information Amount: | unknown | low | **mid** | high | |
| Equip. Components: Number | **not applicable** | 1-3 | 4-9 | 10-14 | 15+ |
| Training Resources: | none | **low** | mid | high | |
| Aiding Technology: | none | low | mid | **high** | |

TASK- WRITE SECURITY POLICE COMPUTER PROGRAMS

SCENARIO

**The change which precipitated the analysis:**

Technological changes have greatly influenced police work. The most pervasive has been the introduction of computers. With computers come the necessity for computer programmers to write the programs.

**Personnel:**

The policemen we are considering have completed a three year enlistment and have re-enlisted for three more years. Their general aptitude scores are in the 40-80th percentile of the ASVAB (Armed Services Vocational Aptitude Battery). This is within a standard deviation of the mean.

**Task:**

Programming computer programs is a complex task involving dozens of substeps. Each of the steps are comparatively easy but the integration of program functions is moderately difficult. Computer programs are written and need modification on a weekly basis. Most of the programs written are for accounting and payroll activities which are not life or mission critical. There is a large amount of information which must be taken into account to write a program, information about syntax, integration and the information which is to be processed. The programs are written on a standard computer keyboard which is similar to a typewriter keyboard.
Environment:

Writing computer programs is performed in an office environment.

**Current methods of support:**

The following resources are available for supporting this task. Security police receive little training and little aiding in this task. Most of the personnel which perform this task have received training in high school or college.

## Profile of 811XX PSTask- Write Security Police Computer Programs

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: | low | **mid** | high | | |
| ASVAB Gen Score | 0 | 40 | 80 | 100 | |
| Personnel Experience: | low | mid | **high** | | |
| Years | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | 4-9 | 10-14 | **15+** | |
| Mental Skills Required: | not applicable | low | **mid** | high | |
| Motor Skills Required: | not applicable | **low** | mid | high | |
| Task Frequency: | daily | **weekly** | monthly | yearly | |
| Task Performance Rate: | not applicable | **low** | mid | high | |
| Task Criticality: | not applicable | **low** | mid | high | |
| Task Hazards: | **none** | low | mid | high | |
| Information Amount: | unknown | low | mid | **high** | |
| Equip. Components: Number | not applicable | 1-3 | **4-9** | 10-14 | 15+ |
| Training Resources: | none | **low** | mid | high | |
| Aiding Technology: | none | **low** | mid | high | |

## TASK- EVALUATE SITUATIONS AT INCIDENT SCENES

## SCENARIO

**The change which precipitated the analysis:**

There have been a number of dangerous situations which have arisen because inexperienced security police have evaluated situations at incident scenes incorrectly. A new directive has been issued that require a senior policeman to be at the scene of all violent incidents.

**Personnel:**

The policemen we are considering have completed a three year enlistment and have re-enlisted for three more years. Their general aptitude scores are in the 40-80th percentile of the ASVAB (Armed Services Vocational Aptitude Battery). This is within a standard deviation of the mean.

**Task:**

Evaluating situations at incident scenes requires a dozen of steps to be quickly followed. There is a moderate amount of both mental and motor skills required. Violent incidents occur on a weekly basis. It is important that the safety of the police is guarded by experienced personnel who know what to look for. There is a moderate amount of information available for assimilation at any incident. The task is highly critical as the safety of security personnel is at stake. There are many potential physical hazards in a violent incident scene, some life-threatening. Security police have megaphones, radios, weapons, etc. to handle serious incidents.

**Environment:**

Situation evaluation is conducted at the incident scene.

**Current methods of support:**

The following resources are available for supporting this task. There is an extensive training school for evaluating incidents. Many incidents are enacted at the schools in a very realistic manner. Security police can communicate via radio to more experienced personnel until they arrive.

## Profile of 811XX Task- Evaluate Situations at Incident Scenes

| | | | | | |
|---|---|---|---|---|---|
| Personnel Aptitude: ASVAB Gen Score | low | **mid** | high | | |
| | 0 | 40 | 80 | 100 | |
| Personnel Experience: Years | low | mid | **high** | | |
| | 0 | 1 | 3 | 3+ | |
| Task Steps: Number | 1-3 | 4-9 | **10-14** | 15+ | |
| Mental Skills Required: | not applicable | low | **mid** | high | |
| Motor Skills Required: | not applicable | low | **mid** | high | |
| Task Frequency: | daily | **weekly** | monthly | yearly | |
| Task Performance Rate: | not applicable | low | mid | **high** | |
| Task Criticality: | not applicable | low | mid | **high** | |
| Task Hazards: | none | low | mid | **high** | |
| Information Amount: | unknown | low | **mid** | high | |
| Equip. Components: Number | not applicable | 1-3 | **4-9** | 10-14 | 15+ |
| Training Resources: | none | low | mid | **high** | |
| Aiding Technology: | none | **low** | mid | high | |

## ATTRIBUTE DEFINITION SHEET

**Personnel Aptitude**: Aptitude is defined as the natural capacity, ability, or suitability of an individual to learn a specified task. In each of the following scenarios, the Armed Services Vocational Aptitude Battery (ASVAB) score represents a composite measure of aptitude types (i.e., mechanical, electrical, etc.). The mean score is 59 with a standard deviation of 17.

**Personnel Experience**: Experience represents the knowledge and skills derived from previous performance the task. It can be acquired through both practice and/or operational performance.

**Task Steps**: The number of individual steps required to perform the task.

**Mental Skills Required**: The mental skills required is a measure of the complexity of the decisions involved with the performance of this task. For example, if there are no decisions to be made (i.e., a fixed sequence of steps is required) mental skills required is not applicable. For simple decisions (i.e., yes/no), the mental skills required is low. And, for decisions which are based on evaluating numerous, inter-related conditions, the mental skills required is high.

**Motor Skills Required**: The motor skills required refers to the difficulty of the physical manipulations necessary to install, remove, adjust, align, and measure the components of the task equipment.

**Task Frequency**: Task frequency refers to how often or frequently this task is performed on the job.

**Task Performance Rate**: Performance rate is the speed at which the task must be accomplished. A major implication of performance rate is whether the person has time to refer to an aid while he/she is performing the task.

**Task Criticality**: Task criticality is a measure of the importance of performing a given task in meeting some goal. Criticality is gauged by the consequences of inadequate performance or nonperformance (i.e., repair expense, loss of time, etc.).

**Task Hazards**: Task hazards are categorized into two types, personnel and equipment hazards. Personnel hazards are characteristics of the tasks which, if improperly performed, can cause injury or death to the performer or others. Equipment hazards are characteristics of the tasks which, if improperly performed, can cause various levels of damage which potentially threaten task accomplishment.

**Information Amount**: The quantity of information the person must process in order to perform the task.

**Equipment Components**: The number of components in the equipment the operator/maintainer employs to perform the task.

**Training Resources**: Training resources include the books, instructors, classrooms, educational software, simulators, etc. which prepare the person for task performance before they do the task.

**Aiding Technology**: Aiding technology refers to the illustrations, tables, flowcharts, checklists, schematics etc. which support the person's performance as they do the task.

## JATAT SURVEY RESPONSE SHEET

Task: Adjust Daily Maintenance Plans to Meet Operational Commitments (B28-1)
Personnel: Jet Engine Maintenance Technicians (454X0)

### PART I. AIDING SOLUTION SPECIFICATION

1. Can aiding techniques be employed to help overcome this problem? (Check one)

   ___ **Yes** (Skip Question 2, go to Question 3)

   ___ **No** (Go to Question 2)

2. If aiding techniques cannot be employed to help resolve this problem, what is it that prevents their use? (Check one and proceed directly to Question 6)

   ___ **Principle**

   ___ **Practice**

   ___ **Policy**

Questions 3 and 4. Given a finite level of aiding resources, how would you allocate them among the following aiding approaches and aiding techniques to most satisfactorily resolve this aiding problem? (Specify relative percentages of resources for each applicable approach/technique: TOTAL = 100 %.)

3. If aiding can be employed to help resolve this problem, what approach(es) to aiding would you use?

   _____% **Display Information**

   _____% **Monitor Performance**

   _____% **Assist Execution**

4. How would you allocate resources among the following aiding techniques to support the approach(es) selected above?

   _____% **Information** _____% **Heuristic**

   _____% **Procedural** _____% **Assistive**

   _____% **Algorithmic**

5. Would this aiding solution alone be sufficient to resolve the problem, independent of any training solution?

   ___ **Yes**

   ___ **No**

PART II. TRAINING SOLUTION SPECIFICATION

6. Can training techniques be employed to help overcome this problem?

   ___ **Yes** (Skip Ques. 7, go to Ques. 8)

   ___ **No** (Go to Ques. 7)

7. If training techniques cannot be employed to resolve this problem, what is it that prevents their use? (Check one and proceed directly to the next Task Scenario. DO NOT answer any of the remaining questions.)

   ___ **Principle**

   ___ **Practice**

   ___ **Policy**

Questions 8 and 9. Given a finite level of training resources, how would you allocate them among the following training approaches and training techniques to most satisfactorily resolve this problem? (Specify relative percentages of resources for each applicable approach/technique: TOTAL = 100 %.)

8. If training can be employed to resolve this problem, what approach(es) to training would you use?

   _____% **Presentation**

   _____% **Modeling**

   _____% **Coaching**

   _____% **Exploration**:

9. How would you allocate resources among the following training techniques to support the approach(es) selected above?

   _____% **Classroom**

   _____% **Independent Study**

   _____% **Simulators**

   _____% **Job Experience**

10. Would this training solution alone be sufficient to resolve the problem, independent of any aiding solution?

___ **Yes**

___ **No**

PART III. COMBINED SOLUTION SPECIFICATION

11. Given a finite level of aiding and training resources, how would you allocate them among the following aiding/training approaches to most satisfactorily resolve this problem?

_____% **Aiding Approaches**

_____% **Training Approaches**